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Railway Age

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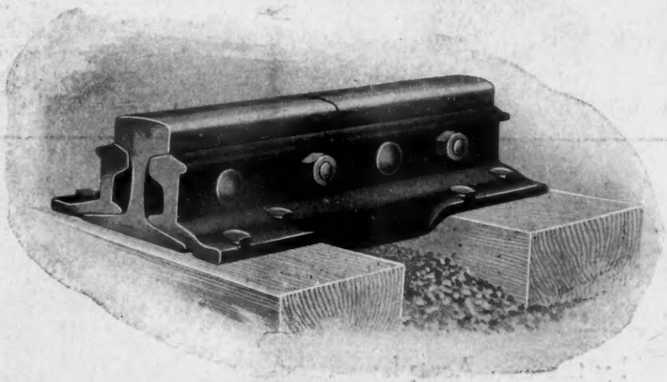

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Railway Age EDITORIAL

DAILY EDITION

The Value of Large Committees

It is to be hoped that the American Railway Engineering Association will not adopt the suggestion which has been made that it follow the practice of the old American Railway Association in the appointment of small committees. Much of the success of the committee work of the Engineering Association has resulted from the exchange of ideas between the relatively large number of men on the committees incident to the consideration of their subjects and the preparation of their reports. It has been said that it is generally the case that a few members of a committee do most of the work. Even though this may be true the detrimental results of inactive members is much greater on a small than on a large committee. Furthermore, the active identification of a large proportion of the members of an organization doing committee work is a source of great strength to that organization. It is also of educational value to the members who have the opportunity of serving on the committees and participating in the discussions.

Water Service Organization

The reports submitted to the convention year after year by the Committee on Water Service are the best possible evidence of the necessity for a radical change in attitude towards this department on the part of many of the railroads. Each year the reports are evidence of the fact that they are the work of experts and that experts must necessarily be employed if the railroads are to derive the benefits that should accrue to them as a consequence of the work and findings of the committees. In the face of these facts it is surprising to note that the common practice of railroads is to organize the water service department as an addition to some other department or branch of the service, and without a responsible directing head. When the importance of the water service to the other departments, notably the motive power and operating departments, is considered it seems that common prudence would suggest the placing of this department on the plane its importance warrants.

Low Unit Stresses

The discussion of the report of the Committee on Iron and Steel Structures developed emphatic opposition to the continuation, in the new rules, of the prevailing method of proportioning structures through the use of low unit stresses in combination with moderate live loadings. The committee made very clear what its reasons were for adhering to this practice, namely, to avoid setting up a high unit stress as standard usage by persons who may or may not be qualified to assume the responsibility thereby incurred. This position is probably justified by the committee's realization of the exceedingly wide use which its specifications have received in the past. However, it is well to call attention to the fact that the practice of making due allowances for future ultimate loadings is not uncommon among railway bridge engineers in their individual practice, and as regards the specific method suggested by Messrs. Irwin and Motley, it is but just to recall that the late C. A. Cartlidge, once chairman of this same committee, put this idea into actual use on his greatest work, the Metropolis bridge.

The Length of Engine Districts

The Committee on Economics of Railway Operation presented an interesting and valuable discussion of the economic length of operating districts in its report submitted yesterday. By implication it approves districts considerably in excess of 100 miles in length. This is in contrast with the marked tendency towards the shortening of engine runs. In the early days of railway operation, particularly on the Western prairie roads, runs of 200 miles were not uncommon. The passage of the 16-hour law, the increasing density of traffic and resulting delays to trains and other influences have tended to shorten these districts until on many of the lines built in recent years, such as the Western Pacific and the Pacific Coast extension of the St. Paul, the average length of district is approximately 110 miles. The present tendency is distinctly towards the shortening of hours of work and this in turn leads to shorter engine districts. For this reason the attitude of the committee is somewhat surprising.

Prompt Publication of Specifications

The preparation of specifications for maintenance of way practices and materials is one of the most important and valuable functions of the American Railway Engineering Association. At the same time it is one which the association must perform with the utmost care, for many of the specifications tend to establish fundamental principles of practice whose influence is far-reaching. For this reason every effort should be made to secure the most complete discussion and consideration of specifications before their final adoption. This in turn requires that the membership be given an adequate opportunity to study the specifications before they are required to pass upon them. The association was called to pass upon no more important question this year than the specifications for steel bridges presented by the committee on Iron and Steel Structures, yet many members of the association were unprepared to pass upon them yesterday owing to the fact that they had received these specifications only a few days in advance of their departure for the meeting, and in many instances they had no opportunity to consider them at all. This is a mistake which has led frequently in the past to action by the association referring the recommendations of committees back for reconsideration and resubmission the following year, owing to the desire of the members to play safe and take no action which further consideration might show to be unwise. Some associations require all matters on which action by the

association is desired to be distributed to the membership at least 60 days before the meeting. Such a provision may or may not be wise, but it has much to commend it. The past year presented many difficulties to committees in the conduct and completion of their work and an unnecessarily heavy load has been thrust upon the secretary's office because of the late receipt of reports. The committees can promote the interests of the association in no more effective way than by completing their reports in ample time for their distribution to the membership well in advance of the annual meeting.

Senator Pomerene's Address

THE PROGRESS WHICH has been made within recent years in the education of leading public men regarding the railway question was very well illustrated by the address which Senator Pomerene of Ohio delivered at the dinner of the American Railway Engineering Association on Wednesday evening.

With some criticisms of the Railroad Administration which Senator Pomerene made, it is impossible to agree. The senator evidently had placed too much reliance upon alleged information regarding the advance in rates which had been furnished to the Senate committee by Clifford Thorne. He evidently had also accepted Mr. Thorne's well known views regarding the purpose and effect of some other things the Railroad Administration has done. The public man who takes either Mr. Thorne's information or views at their face value is pretty sure to go wrong regarding the particular matters to which they relate.

Senator Pomerene's address made it clear, however, that he has got a comprehensive grasp of the railroad problem and if the minds of the majority of the members of Congress are moving in the same direction that his is, a satisfactory solution of the problem should be reached in a comparatively short time in case Congress is convened early in extra session. Senator Pomerene very properly criticised the attempt to continue government operation for the purpose of making an experiment when government control was adopted, not to prove or disapprove the advantages of government operation, but solely as a war measure. He recognized the fact that the laws need to be changed so as to permit such agreements and consolidations between the railways in the same territory as the Interstate Commerce Commission may deem not prejudicial to the public interest.

He advocated government regulation of the issuance of railway security issues, a policy which all students of the subject now favor. He implied that he would favor similar provision which would establish a definite standard by which the regulating bodies in fixing rates should be required to measure their reasonableness and adequacy and it seems reasonable to infer from his address that he would be in favor of requiring the railways to be permitted to earn an average of six per cent upon the investment of their properties. There was little criticism of private management of the railways in his address and much criticism of government management.

Senator Pomerene is a Democrat, but he and many of the other leading Democrats in Congress agree with the leading Republicans in opposing government ownership and in favoring the return of the railways to private operation under legislation which will enable them to render better service and operate more efficiently and at the same time adequately increase their facilities. There is a striking difference between the addresses on the railroad question which were being made by leading public men a few years ago and the addresses which are being made now. This change must, and in fact does, reflect a great change in public opinion and with public opinion what it is now, there is good grounds for hoping that a satisfactory solution of the railroad problem will soon be found in spite of the fact that the situation existing at this particular time is the worst, as a whole, that has existed for 25 years.

Automatic Train Control

THE AUTOMATIC TRAIN CONTROL COMMITTEE appointed by the Railroad Administration has been in attendance at both the stated meeting of the Signal division of the A. R. A. and the annual meeting of the A. R. E. A. The instructions to the committee were to make a study of and report upon automatic train control devices which have been installed or which may be practicable. The work of the committee includes among other things the study of plans covering such devices; the drawing up of requisites as a guide for such study; the inspection of such devices as have been installed, and the making of recommendations covering the installation and further test of such apparatus. Certain requisites in the past have been so drawn that they have hampered the development of devices of this character, but it has been realized to be a mistake to attempt to draw up stringent requisites on theoretical assumptions which are not backed by practical experience.

The tentative requisites presented by the present committee are along more proper lines and instead of restricting should tend to encourage development work. They may perhaps not include all that is desired and may appear to be conflicting in certain instances, but they are good as a basis for a start and can be revised or added to as occasion demands. The committee inspected the automatic train control exhibits at the Coliseum yesterday afternoon and to-day it starts on the first of its inspections of the automatic stops already installed.

Progress in Scientific Knowledge

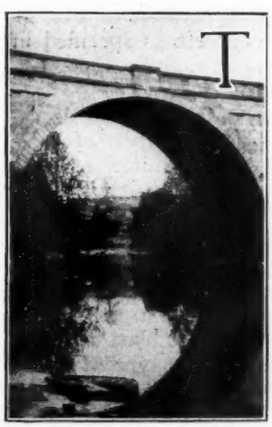
THE MATERIAL presented by the Committee on Masonry on considerations affecting the strength of concrete, when considered in the light of other information brought forth during the past 20 years, drives home the fact that the pioneers in the use of concrete were compelled to proceed in their work with extremely limited knowledge of the materials with which they were dealing. As the result of facts developed from time to time, practices in construction have gone through numerous transitions. We have turned from dry concrete to wet concrete and now appear to be turning again to dry concrete. In view of some of the startling developments brought out in the course of experimentation, one is inclined to wonder at the courage of the early builders in concrete. Perhaps they enjoyed a condition of blissful ignorance. At any rate most of their structures have withstood the tests of use and time, but the large factors of safety which their caution (in the absence of exact data) urged them to use, may be largely responsible for their success. This raises the question of the justification for proceeding with such limited information that efficient designs were not practicable. Has an economic waste resulted from the use of what we now consider wasteful designs? The answer is that more economic waste would have resulted if engineers had refrained from using concrete until more of its real properties were known. In fact, the properties would never have become known had men been too cautious in the use of the material. Progress comes from using the resources at hand, however imperfect, since the ideal will never be attained.

American Railway Engineering Association Proceedings

A Report of Thursday's Sessions, Including the Presentation of Seven Committee Reports and Closing Business

THE TWENTIETH ANNUAL CONVENTION of the American Railway Engineering Association drew to a close on Thursday. The morning session was called to order at 10 o'clock by Vice-President Stimson, President C. A. Morse still being confined to his room by illness. Reports were presented on Iron and Steel Structures, Masonry, Water Service, Wooden Bridges and Trestles, Uniform General Contract Forms, Economics of Railway Operation and Economics of Railway Location. These were followed by routine business and the installation of the new president, Earl Stimson. Abstracts of the reports and the discussions are given below.

Report of Committee on Masonry



THE COMMITTEE has no recomendations to make at this time. The question of revising the definitions in the Manual has received consideration and it was decided to completely revise this portion of the Manual next year.

A report on different methods of depositing concrete under water is given in Appendix B.

A report on specifications for slag aggregate is given in Appendix D.

A report on: (1) The effect upon the strength and durability of concrete not having a sufficiency of moisture present throughout the period of hardening as compared with concrete fully supplied with moisture. (2) Methods of providing moisture during the period of hardening and (3) Remedy for concrete hardened with insufficient moisture, is given in Appendix E.

Committee: F. L. Thompson (I. C.), chairman; J. J. Yates (C. R. R of N. J.), vice-chairman; R. Armour (G. T.), G. E. Boyd (D., L. & W.), H. A. Cassil (P. M.), C. S. Coe, T. L. Condron (Cons. Engr.), J. K. Conner (L. E. & W.), C. S. Davis (Pa. Lines), J. L. Harrington (Cons. Engr.), W. K. Hatt (Purdue Univ.), L. J. Hotchkiss (Cons. Engr.), Richard L. Humphrey (Cons. Engr.), Noah Johnson (Wab.), M. S. Ketchum (Univ. of Colo.), W. M. Kinney, W. S. Lacher (Ry. Age), A. E. Owen (C. R. R. of N. J.), W. M. Ray (B. & O.), C. P. Richardson (C., R. I. & P.), G. H. Scribner Jr., F. P. Sisson (G. T.), J. E. Smith (Univ. of Ill.), Job Tuthill (P. M).

Appendix B—Depositing Concrete Under Water

The committee does not feel that any definite conclusions can be presented at this time. There is, however, some data which it believes desirable to present as representing its opinion as to the best practices to be followed in depositing concrete under water.

In general, where it is possible, the depositing of concrete under water should be avoided, even if such action results in aditional expense and possible delay to the work. The need of close supervision by men competent to handle this class of work is of the utmost importance, and concrete should never be deposited under water without experienced supervision. Many failures which have occurred in concrete deposited under water, especially where the structure is located in sea water, can be directly traced either to ignorance or lack of supervision.

Of the methods used, the following seem to give the best results:

1. The concrete is lowered in large buckets having a hinged bottom which sets sufficiently far above the lower edge of the bucket so that it may open freely downward when the bucket reaches the surface upon which the concrete is to be deposited. The top of the bucket is left open, and care is taken to see that the bucket is completely filled before lowering.

2. The concrete may be passed through a vertical tube or tremie reaching down to the surface upon which the concrete is to be deposited.

3. Jute or cloth bags, from two-thirds to three-fourths

filled, have been used successfully. These are placed in a header and stretcher system so that the whole mass is interlocked.

4. Where it is difficult to construct a cofferdam or monolithic work is not required, premolded concrete blocks of large dimensions have been used successfully.

5. A concrete depositing bag made of canvas or other suitable material is a variation of the bucket system. This is filled and the mouth of the bag closed by one turn of a line so looped that a pull on the line will release it. The bag is lowered mouth down to the surface upon which the concrete is to be deposited, and a sharp pull on the line opens the bag and permits the concrete to be deposited. This method does not have the disadvantage of the closed top bucket, since the bag will collapse as the concrete flows out.

There are a number of other methods that have been used, such as depositing directly through the water; depositing a portion of the concrete by one of the above methods in the corner of the form and the balance progressively from wheelbarrows or buckets on the sloping surface, thus gradually filling the form; allowing the concrete to partially set in air and then depositing it in a plastic condition; depositing the concrete dry without the use of water; attempting to grout a foundation composed of riprap or coarse gravel by means of pipes sunk at intervals into the foundation. Although occasionally fair results have been obtained, all of these methods are dangerous, as they almost uniformly result in segregation of the materials or the washing out of the cement.

In depositing with drop bottom buckets, the drop bottom bucket should be so arranged as not to discharge the load until the bucket reaches the surface upon which the concrete is to be deposited. In lowering the bucket, care should be taken that unnecessary wash is not produced. This may be avoided by slowing up the operation when the bucket is passing through the water. The bucket, when the load is discharged, should be withdrawn slowly until clear of the concrete. In depositing concrete under water by this method it is imperative that the work be continuous and sufficiently rapid to insure bonding of the successive layers.

In depositing through tremie or vertical tubes the device should be about 14 or 16 in. in diameter, made up in sections so that the length may be adjusted to the depth of the water. The joints should be made flanged and the tube put together with gaskets, in order to avoid leakage of the water into the tube. The top should be flared, in order to receive the concrete properly. The tube should be suspended in such manner that it may be moved laterally as required. The upper end is placed near the level of the working platform, while its lower end rests on the surface upon which the concrete is to be deposited. When the operation starts the tube should be filled in such manner that the concrete is not permitted to drop down through the water. This is accomplished in several ways: One is to place the bottom of the tube in a box, partially filling it with concrete so as to seal the bottom, then lowering the box into the position in which it is to be used. One requisite of this method is that the tube must at all times be kept filled with concrete and the greatest care exercised to see that the charge is not lost in moving it about the bottom.

While the bagging method insures good concrete and will prevent the formation of laitance, it is open to the objection that a monolithic foundation is not secured. Where the walls of the foundation formed by the bags will not be exposed to scour, the opinion is that the method will give satisfactory results. This method can be used to advantage in sealing the foundations of cofferdams where it is impracticable to prevent inflow of water through crevices in the bottom. In using this method it must be borne in mind that satisfactory results cannot be obtained unless the bags are carefully placed by hand.

Premolded concrete blocks can be used to advantage on a prepared foundation in any heavy construction where the units can be large enough not to require bonding.

Concrete to be deposited in water should be of a richer mixture than when deposited in air, and a leaner mixture than 1-2-4 should not be used. It is the opinion of the committee that only so much water should be used as will make the concrete of a plastic consistency. It is the opinion of the committee that washed gravel of somewhat smaller size than used in the open air concrete will give the best results. The aggregate should be capable of producing dense concrete.

In depositing concrete under water it is imperative that the water be still and that the concrete shall not be exposed to current until it is fully set. One of the essentials of depositing concrete by any of the above methods is that the concrete be disturbed as little as practicable during the depositing, thus avoiding the formation of laitance. When a job is started the concrete should be deposited continuously until the finished surface is reached or the concrete brought above the water level so that the laitance may be removed in the air. The formation of horizontal construction joints under water should be avoided. Concrete should be thoroughly mixed before it is deposited in water and, therefore, hand mixing should never be permitted.

Appendix D—Specifications for Slag Aggregate

After a study of the data available on the properties of slag and of specifications for slag as an aggregate in concrete, your committee does not feel warranted in submitting a specification for adoption by the Association. The following discussion of this subject is submitted as information. This applies to the use of slag as the *coarse* aggregate only.

The committee believes that the general requirements for coarse aggregates for use in concrete as specified in paragraph 4, page 282, of the Manual, may be applied to blast furnace slag without modification.

Further requirements for slag in current specifications examined cover such matters as origin, method of cooling, age, weight, strength and chemical limitations. At the end of this report a table is presented which lists the requirements of ten specifications for slag to be used in concrete and which demonstrates a marked lack of uniformity. We offer the following comments:

As to origin, only two specifications definitely called for blast furnace slag, all others read so as to permit the products of the steel furnace as well as the blast furnace.

Air cooling is general and represents the type of material desired. This can be required without causing any commercial difficulties. When it comes to the matter of age or time of seasoning, the case is not so clear and the requirements vary. Some specifications demand a year's seasoning, others permit the use of the material after two or three weeks. The necessity for this depends on the nature of the slag. According to Sanford E. Thompson, a limestone slag (one containing only 1 to 2 per cent of magnesia) is not stable until seasoned for considerable periods, while a magnesia slag (one containing 4 per cent or more of magnesia) is commonly used within two or three weeks after banking, as no chemical change is apparent on exposure.

The weight is the most definite requirement and concerning which there is the greatest uniformity. Seventy pounds per cu. ft. would seem to be a conservative yet reasonable figure.

Strength requirements are considered as impractical and without adequate precedent. Those discovered apply only to materials to be used in pavements where resistance to abrasion or surface impact is important.

Chemical limitations are placed in specifications for slag presumably to exclude materials containing unstable compounds or elements of a disintegrating or corrosive nature. The content of sulphur receives the widest attention in this regard and the limitation has been variously stated at from 1 to 2 per cent where it is covered in the specification.

The presence of unslaked lime seems to be of more vital importance since the presence of this material would obviously tend toward unsoundness of the slag on exposure to moisture unless neutralized by acid ingredients. It is because of this that some specifications place the limitations on the lime content and specify a minimum amount of silica to insure that enough of the SiO_2 radical shall be present to stabilize the CaO. As some users of slag are of the opinion that the seasoning of the material in a bank exposed to the weather would insure the elimination of any free lime and as there appear to be no test data available tending to demonstrate the adequacy and efficacy of these chemical requirements for sulphur, lime or silica, the committee does not feel qualified to make any definite recommendation in this regard.

In using slag in concrete it is necessary to include a requirement in the specification for the concrete that will insure proper proportions. Very strong concrete may be made with slag if the proportion of cement and fine and coarse aggregates are such as to provide high density, but owing to the porous nature of most slags, somewhat larger quantities of cement and fine aggregate will be required to obtain the desired density than is the case of most ordinary materials used as coarse aggregates.

Specification Requirements for Slag

Authority	Strength	Origin	Air Cooled	Age	Weight lb. per cu. ft.	Sulphur Not Over Per Cent	Lime, Not Over Per Cent	Silica, Lot Less Than Per Cent
New York Central		Blast Furnace	Yes	2 mo.	70	1.7*	48	33⅓
Sanford E Thompson			Yes		65†	1.7	48	32
Central of Georgia				1 yr.				
Viaduct Cuyahoga County, Ohio	‡				74			
Bldg. Spec. Philadelphia		Blast Furnace	Yes		75	1.3		
Ohio State Highways A	Toughness not less than five				70	1.5	45	32
Ohio State Highways B	Toughness not less than five				65	2.0	45	32
Ohio State Highways C						2.0	45	30
Youngstown City Engineer			Yes	Lime slag 3 months Mag. slag less	68			
U. S. Department of Agriculture					70			

*No free sulphur, chemical analysis every 2,000 cu. yd.
†After shaking to refusal.
‡Abrasion loss not more than ten. Factor of hardness not less than twelve. Factor of toughness not less than six.

Appendix E—Effect of Quantity of Mixing Water and Curing Conditions on the Strength and Wear of Concrete

A series of tests made by Professor D. A. Abrams at the Structural Materials Research Laboratory, Lewis Institute, Chicago, show the importance of proper storage during the early hardening period, both on the wearing qualities and strength. The results of these tests indicate that with small specimens a few days' moisture is helpful to the strength and wearing qualities, while provision for moisture for several weeks will produce results almost equal to those which would be obtained with continuous favorable storage conditions.

While the results on small specimens only approximate the results to be expected where large masses of concrete are used, it is not unreasonable to assume that particularly where the concrete is to be used as a wearing surface, great improvement in the strength and wearing qualities can be obtained by providing moisture to the hardening concrete for several weeks after the concrete is mixed and placed. In mass concrete, while provision for moisture is desirable and should be encouraged where practicable, it is not absolutely imperative as mass rather than high stregnth is sought.

In all reinforced concrete structures, however, some provision should be made to prevent the rapid drying out of the concrete, which almost invariably occurs during the summer months. All concrete should be protected from the direct rays of the sun and unless the expense is absolutely prohibitive, sprinkled for from several days to several weeks, depending upon the character of structure.

Moisture can best be provided to hardening concrete by covering the concrete with earth, sand, straw or other moisture-retaining material and sprinkling this covering at least night and morning for from one to two weeks after the concrete has been placed. If the days are real hot, additional sprinklings during the day will be required and the covering should be thicker so that drying out will take place less rapidly.

Concrete which has hardened with insufficient moisture can be improved somewhat by sprinkling even after it is several weeks old. The most serious result from failure to provide moisture occurs with sidewalks, floors, station platforms, etc.

Discussion

(F. L. Thompson (chairman) presented the report.)

Prof. A. N. Talbot (U. of Ill.): Concrete is a complex material. There are many elements entering into its strength and quality. I have jotted down a few items concerning some of the elements which go into the making of concrete at the beginning, and I want to present them to you. They may seem elemental to some, and yet it does seem to be worth while to give consideration to the question as to why additional water gives reduced strength, why voids in the aggregate reduce strength, why surface area of the aggregate itself, a larger amount of that, will tend to reduce strength. Here are the items.

1. The cement and the mixing water may be considered together to form a paste, which becomes the glue that holds the particles of aggregate together.
2. The volume of the paste is approximately equal to the sum of the volume of the particles of the cement and the volume of the mixing water.
3. The strength given this paste is dependent upon its concentration; the more dilute the paste, the lower its strength; the less dilute, the greater its strength.
4. The paste coats or covers the particles of aggregate partially or wholly and also goes to fill the voids of the aggregate partially or wholly. Full coating of the surface and complete filling of the voids are not usually obtained.
5. The coating or layer of paste over the particles forms the lubricating material which makes the mass workable; that is, makes it mobile and easily placed to fill a space compactly.
6. The requisite mobility or plasticity is obtained only when there is sufficient paste to give a thickness of film or layer of paste over the surface of the particles of aggregate and between the particles sufficient to lubricate these particles.
7. Increase in mobility may be obtained by increasing the thickness of the layer of paste; this may be accomplished either by adding water (resulting in a weaker paste) or by adding cement up to a certain point (resulting in a stronger paste).
8. Factors contributing to the strength of concrete are then the amount of cement, the amount of mixing water, the amount of voids in the combination of fine and coarse aggregate, and the area of surface of the aggregate.

9. For a given kind of aggregate the strength of the concrete is largely dependent upon the strength of the cement paste used in the mix, which forms the gluing material between the particles of aggregate.

10. For the same amount of cement and same voids in the aggregate, that aggregate (or combination of fine and coarse aggregates) will give the higher strength which has the smaller total area of surface of particles.

11. For the same amount of cement and the same surface of aggregate, that aggregate will give the higher strength which has the less voids, since additional pore space will involve a more dilute paste.

12. Any element which carries with it a dilution of the cement paste may in general be expected to weaken the concrete—smaller amounts of cement, the use of additional mixing water to secure increased mobility in the mass, increased surface of aggregate, and increased voids in the aggregate all operate to lower the strength of the product.

A certain degree of mobility is necessary in order to place concrete in the forms in a compact and solid mass, the degree varying considerably with the nature of the work; and we must accept it as true that generally it will be found necessary to sacrifice strength to secure the requisite mobility.

More thorough mixing not only mixes the paste and better coats the particles, but it makes the mass mobile with a smaller percentage of mixing water and this results in higher strength. Any improvement in method of mixing which increases the mobility of the mass will permit the use of less dilute paste and thereby secure increased strength.

B. R. Leffler (N. Y. C.): The report recommends one minute and a half as the time for mixing the concrete. We tried that on a large job. We finally compromised by cutting it down to a minute. Our observation showed that under the ordinary loose methods the time of mixing was ordinarily about 15 or 20 sec. The time of mixing is an important feature in regard to the lubrication of the particles of the aggregate, so as to produce plasticity and ready flowing of the concrete. I think within certain limits it will be found that the desired plasticity can be attained with the least amount of water and the proper time of the mixing. The use of excess water is purely a contractor's method of placing the concrete with the least expense. The question of the proper time of mixing is dependent on the kind of concrete mixer used, and I think that is an important subject for investigation.

G. W. Kittridge (N. Y. C.): I want to say a word in commendation of the report and the discussion by Prof. Talbot. I think such a discussion as Prof. Talbot has given is what makes the proceedings of this association of such great value to its members and the public generally.

(The committee was dismissed with thanks.)

Report on Wooden Bridges and Trestles

THE COMMITTEE HAS no recommendations to make as to the subject-matter in the Manual except in the way of intensive revision and re-writing of the entire chapter on Wooden Bridges and Trestles. It is not thought expedient to advise such revision at this time or at least until a new edition of the Manual is issued.

The especial consideration of expanding the table of allowable stresses on page 244 to include treated timber has been given extensive study during the past year. An investigation of experiments for determining the comparative strength values of untreated and treated timber in large sticks discloses the fact that there are extant only two published records of such experimental tests. One of these is to be found in Bulletin Number 286 of the United States Department of Agriculture, and the other consists of a monograph by H. B. McFarland, engineer of tests for the Atchison, Topeka & Santa Fe, beginning on page 281, Volume 17, of the Proceedings of the Association.

Until further experiments have been conducted in the way of comparing treated and untreated timber in large sticks, it is perhaps best for each engineer to use his own judgment as to the lower values of allowable stresses which should be applied in the design of treated timber trestles, keeping in mind that such values may be as much as one-third lower than for untreated material.

Specifications for Timber and Building Lumber

Our investigations and studies during the past year lead us to believe that an entire rearrangement of the chapter on Wooden Bridges and Trestles, as now published in the Manual, would be profitable. We also are of the opinion that a separate chapter to be headed "Timber and Lumber," which should contain general specifications and classification and grading rules for all kinds of timber and lumber to be used for each of the different classes of work on railways, might well be published in the Manual.

To this end the committee submitted tentative general specifications and classification and grading rules developed during the study of this work for the past year. These specifications have been drawn up after careful consideration and a thorough study of the work now standing in the Manual; recommendations and reports of committees as published in the Proceedings, especially the Special Committee on Classification and Grading Rules; the specifications of the American Society of Testing Materials; the work of the United States Forestry Board; reports of laboratory studies from various scientific institutions; a detailed study of the Standard Specification and Grading Rules of all the lumber manufacturers' associations, and various other sources.

It has been the attempt to draw up such general specifications that they might be referred to as standard for material of this kind under all circumstances. Special attention has been given to standard manufacturing processes so that no decided changes will be necessary in the best practices now followed by the manufacturers, yet satisfactory material may be obtained by the railways at reasonable prices. (These suggested tentative specifications were then presented as information.)

Committee: W. H. Hoyt (D. M. & N.), chairman; A. O. Ridgway (D. R. & G.), vice-chairman; H. Austill, F. Auryansen (L. I.), A. D. Case, E. A. Frink (S. A. L.), W. L. Darden (S. A. L.), E. A. Hadley (U. S. R. R. A.), G. A. Haggander (C. B. & Q.), F. F. Hanly (B. & O.), H. T. Hazen (C. N.), C. S. Heritage (K. C. S.), F. S. Schwinn (I. & G. N.), C. S. Sheldon (P. M.), I. L. Simmons (C. R. I. & P.), D. W. Smith (H. V.), A. M. VanAuken (B. & O. C. T.), W. H. Vance (St. L. S. W.), D. R. Young (D. L. & W.).

Discussion

W. H. Hoyt (Chairman): With regard to the report of the sub-committee considering the question of unit stresses for treated timber, I wish to bring out the fact that there have not yet been at this time any extensive tests made anywhere upon large-sized sticks, comparing the treated timber with untreated timber. We found we

had only two sets of tests and these varied considerably. In the matter of a unified form of specifications for construction timbers and building lumber for use on railways, the question was raised as to just what was meant or how this question should be handled. The committee attempted to draw up a general specification that might be used as a basis for drawing up any particular specification that might be needed. This was for the purpose of trying to keep down in volume the size of the specification as published in the Manual. In other words, we tried to standardize the specification. The thing that we wanted to do was not to draw details that would be hard to manufacture, or would be subject to and require special arrangements, and consequently higher cost. Therefore, we consulted carefully the specifications of all the manufacturers' associations and tried to embody in this general specification a basis from which we could draw any particular specification required. One can very easily see that if we attempted to draw up a special specification for every kind of timber and lumber being used, a specification complete in itself, it would make a much larger book than our present Manual.

W. H. Courtenay (L. & N.): The committee points out that some railways use one kind of timber, supposed to be convenient to them, and have specifications for that particular kind of timber. Other railroads may use various kinds of timber.

Mr. Hoyt: Of course, that is true. In different parts of the country different kinds of timber are used on different railroads. If we were to attempt to draw up a detailed specification of each kind of timber, it would not only be bulky, but would only cover particular locations. It was that point of view that the committee had in mind in trying to concentrate and draw a general specification that might be used as a basis from which detailed specifications could be drawn to cover particular locations and particular roads. The committee simply submits this report for this year as a progress report and study, and hopes to continue it next year.

(The committee was dismissed with thanks.)

Report of Committee on Water Service

THE COMMITTEE REQUESTS:

1. That the changes in subject-matter on Water Service under the heading "Revision of the Manual" (Appendix A), be adopted and substituted for matter now given in the Manual.

2. That the report on progress of regulations with reference to purity of drinking water furnished on trains and premises of railroads (Appendix B), be received as information.

3. That the final report on impounding reservoirs (Appendix C) be received as information.

4. That the matter of plans and specifications for typical water station layouts be given more definite title.

5. That the report on meters (Appendix D) be received as information.

6. That the report on locomotive flue failures and methods of correcting water conditions (Appendix E) be received as information.

7. That the report on rules and examination questions for care of pumping stations (Appendix F) be adopted by the association and inserted in the Manual.

Suggested Subjects for Next Year's Study and Report

1. Report on suitable methods for chemical storage at water softening plants.

2. Report on progress of regulations and methods for supplying pure water for drinking purposes on trains and premises of railroads.

3. Study of economies to be derived from impounding reservoirs.

4. Report on methods of supplying drinking water to passenger equipment with smallest possible opportunities for contamination.

Committee: A. F. Dorley (M. P.), chairman; J. L. Campbell (E. P. & S. W.), vice-chairman; J. T. Andrews (B. & O.), R. C. Bardwell (M. P.), J. M. Brown (C. R. I. & P.), C. Bucholtz (Erie), E. M. Grime (N. P.), W. C. Harvey (C. G. W.), C. R. Knowles (I. C), E. G. Lane (B. & O.), E. H. Olson (A. T. & S. F.), W. A. Parker (St. J. & G. I.), H. N. Rodenbaugh (Sou.), R. W. Willis (C. B. & Q.).

Appendix A—Revision of Manual

Pages 450 and 451—Suggested Revision: Foaming and Priming

"Foaming" is the term applied to the action of a boiler when the steam bubbles up over the surface of the water to such extent that the steam space and dome are filled, and syphoning action is started which causes water to be carried over with the steam into the engine cylinders. Under these conditions steam loses much of its expansion properties and the effective operation of the locomotive is thereby materially impaired.

This action is due primarily to the presence of suspended matter in the water. The suspended matter gives a mechanical strength or tenacity to the liquid in the thin films over the steam bubbles, which, rising to the surface, retain their films and collect to produce foam. It is aggravated by the concentration of alkali salts present in the natural waters or added by the process of water softening, which increases the viscosity of the surface films.

The concentration of foaming salts reaches a critical point between 100 and 200 grains per gallon, depending upon the character of the alkali salts and the amount of suspended matter in the water. To prevent foaming the concentration must be kept below this point. The best results are obtained by the systematic and frequent blowing off of the boilers, and occasional complete blowing down and washing boilers at terminals. The cost of maintaining the concentration below the critical point equals the cost of pumping, treating, and heating to boiler temperature the amount of water necessary to be blown out.

When the unavoidable concentration of foaming salts is so great that the required amount of blowing off is impractical or uneconomical, anti-foaming compounds can be used with good results.

"Priming" is the sudden evolution of steam from a heating surface which throws water in sudden, large volumes up into steam space, and is due either to poor design of the boiler and to its being worked beyond capacity, or to the sudden opening of the throttle. While the effect upon the locomotive is temporarily the same, priming is different from foaming and can be mechanically

controlled to large extent by proper handling of the engine.

Appendix C—Design of Impounding Reservoirs and Conditions Under Which They Are Economical

Reservoirs used for supplying water for railroad purposes generally require comparatively small drainage areas and obviously stream flow operations are very limited and probably in the majority of cases entirely lacking, consequently the application of some method based on other obtainable physical data is highly desirable; but this should be supplemented by at least some short term stream flow records. Generally impounding water supply reservoirs are economical and justified at such points or places where the cost of the water so furnished does not exceed that of any other usable and equally dependable supply. They are the chief source of water supply in localities where the surface streams have intermittent flow, where the water in surface streams is too bad for treatment, where the sub-surface supply is insufficient or untreatable, and where there is sufficient rainfall to produce an adequate surface run-off.

The classes of impounding reservoirs referred to in this article relate to those situated in draws or small valleys supplied by surface run-off only and having comparatively small drainage areas, and where the watershed contains no bodies of water other than the reservoir. If possible a site should be chosen for the reservoir which is higher than the point at which the water is to be delivered, thereby securing the much-desired gravity pipe line. The gravity feature of a reservoir is worth the capitalized value of pumping which can either be put in pipe line or reservoir.

In general no site should be selected which has a drainage area of less than 2.50 square miles, with a deep and steep storage basin permitting a water depth of at least 25 ft. However, local conditions may vary this. The ratio between the land area of a watershed and the high water contour in a proposed reservoir should be not less than 35, preferably not less than 40. The surface character of the watershed should be such that a maximum surface run-off is secured. This condition in general calls for a drainage area of rather steep slopes of impervious material and non-cultivated surface and of principally short grass vegetation, thereby reducing silt to a minimum. Matters of watershed jurisdiction, possible water pollution and water diversion should be carefully considered, as well as favorable dam and spillway sites.

The capitalized value of the cost of furnishing water should be ascertained both for present consumption and twice and three times present supply, being sure to take all cost items into consideration, the following being suggested items, viz.: Cost of present plant and equipment. Cost of future additions. Interest on cost. Renewals. Maintenance. Operation (includes treatment). Cost of water when purchased. Economical benefits from improved quality.

Knowing the actual total present cost of water and having estimated the cost of double and three times the present consumption, we will then have figures serving as guides in determining the approximate limiting permissible expense that might be profitably invested in an impounding reservoir.

Approximate estimates should now be prepared and if the project is found to be feasible, more detailed study should be made of all contributary factors in somewhat the following order:

The maximum present and near future demands should be known. The history of the increase in traffic on the particular line on which the water station is to be located should be known. If traffic history is not available, it is reasonably legitimate practice to design the reservoir for at least twice the immediate or near future demands for intermediate main line stations and at least three times for terminals. On some main lines the terminals or division points double their water requirements about every ten years, while at intermediate points this occurs every 20 to 25 years. No reservoir (even on branch lines) should be constructed that is not capable of supplying at least twice the present or near future demands.

The size and character of the drainage area will necessarily be largely governed by the local topography and precipitation. The surface should be of non-porous soil and steep slopes, as previously mentioned, thereby securing a high rate surface run-off. The watershed should include no closely inhabited area. The sub-surface run-off is neglected in this discussion as far as it pertains to the furnishing of a water supply to the reservoir. Excessive drainage area should be avoided as this is conducive to lack of control or jurisdiction, thereby increasing liability to pollution; also an excessive watershed may entail a large and costly spillway. The size of the drainage area should be carefully ascertained. The elevation of the water table should be determined at several places, including a point near the dam site.

The site should be as close as possible to the point of consumption. Its shape should be such that a minimum water surface is exposed to evaporation. It would be desirable to have it surrounded with timber to break up the winds and throw a maximum amount of shade on the water surface. The reservoir should be carefully examined as to the impervious character and dip of the strata of material that constitute its bed and banks, having in mind the securing of as nearly as possible a watertight storage basin. Its shape should be deep and contracted with steep banks and flat bottom, generally the minimum water depth should be three times the water evaporation plus the seepage, but in no event less than 25 feet. This gives a little leeway for silting.

One of the first things to do is to establish a relation between rainfall and surface run-off to serve a check on the computations. Some method of gaging the discharge from the particular drainage area should be maintained during at least several successive rains. Get the average and the annual rainfalls from the oldest weather station in the district. Examine for occurrences of two successive or single drought years and whether they were preceded by one or two or more years of average rainfall, then do likewise for several of the nearest surrounding weather stations. Then compare the monthly rainfalls at the same stations for the prospective period to be studied. Now select from the data collected two successive years having average rainfall and succeeded by one or two drought years and if there is reasonable agreement between the several stations get the daily rainfall records from the one nearest to the watershed and most likely to be in the path of the rainstorms reaching the drainage area for the two average years and the drought period. It is generally a good plan to go back one extra year and to include the year succeeding the drought period.

The evaporation from land areas usually is the most important factor in determining run-off from a watershed. It varies with the rainfall, season, temperature, slope, humidity, vegetal cover, wind, topography, surface and subsoils. Of these, temperature is the most important factor governing the rate of evaporation, as the rate of evaporation from land varies closely with the temperature.

Frequent light rains keep the surface soil and vegetation moist, thus favoring greatest evaporation, while

slow, steady rains favor ground percolation. Torrential rains favor surface run-off. All forms of vegetation reduce the rate of evaporation of free moisture, particularly due to the shading produced. The annual land evaporation loss varies from about one-quarter to two-thirds of the yearly rainfall.

Transpiration is a process of evaporation of water from the breathing pores of leaves and other vegetable surfaces. It is practically limited to daylight hours and to the growing season. The amount of water used by plants during the growing season depends mainly on the quantity available within reach of the root system. In estimating the transpiration loss from a watershed the exact character of the vegetation is not as important a factor as it might first appear except for lands in arid and semi-arid regions. Nearly all watersheds have mixed vegetation and consequently it does not vary between considerable limits. For tentative purposes 6 to 10 in. may be used for the entire area for the season.

Heavy rates of precipitation cause large surface flow. Substantially all of the rain falling upon frozen, ice-covered ground will run off into the water course and when carrying ice and snow with it in sufficient quantities the surface flow may exceed the rainfall.

In spring and fall when the land evaporation and transpiration losses are small all soils, as a rule, carry substantially the entire possible amount of capillary water, between rains. Under such conditions the capacity of sand for gravity water is about four in. per vertical ft., while the capacity of heavy clay is but a little more than one in. per vertical ft. In consequence of which clay soils quickly become saturated and thereby permit large surface flow. Tilled land will facilitate ground absorption of the rainfall, thus reducing the surface flow. Surface flow resulting from moderate rains is retarded and to some extent diminished by lakes, ponds or holes no matter how small they are.

On the Mississippi River watershed (except possibly near the Gulf of Mexico) and throughout the greater part of the United States, the normal rainfall is insufficient to supply the needs of transpiration and land evaporation at the prevailing temperatures; consequently, a large portion of any increased rainfall goes to supply unsatisfied needs of transpiration and land evaporation and hence a comparatively small portion of the increased rainfall, within certain limits, appears as run-off.

The water contributed to streams as seepage flow consists of ground water supplied by percolation. Not all the percolating water, however, reaches the streams; portions are lost through evaporation, transpiration and a small varying amount to deep seepage. When the capillary water has become wholly or partly depleted through evaporation and transpiration, percolation must first replenish the capillary water before the soil will permit gravity to draw water down into the ground water reservoir which supplies the seepage flow of streams. Capillary water amounts to about ½ in. sand and 3 in. in heavy clay per foot in depth. Clay soils retard percolation and facilitates surface run-off.

When the rainfall is insufficient to keep the ground continually moist, which is usually the case, the character and rate of rainfall are the factors which most largely influence seepage flow. When there is no frost in the ground, or the ground was relatively dry when it froze, slowly melting snow permits of the greatest percolation. On the whole, a greater proportion of snowfall than rainfall eventually percolates into the ground to supply seepage flow. Next to snowfall in effectiveness in replenishing the ground water supply are the slow, drizzling rains that occur over large portions of the country during spring and fall, when both evaporation and transpiration demands are relatively small.

The increase in seepage flow which will result from a given increase in the ground water supply, through percolation, will depend upon the slope of the ground water surface and the resistance of the subsoil to the flow of water. Fine grained subsoil will maintain a steeper water table than coarse grained material, due to the difference in resistance to flow.

Appendix D—Suitable Types of Water Meters for Use in Railway Water Service

Many devices have been proposed for measuring water. Some devices measure water by volume, that is to say, a chamber of a given size is filled and emptied continually, and the number of times it is filled and emptied. A second class of meters is that known as "current" meters. These meters measure water by recording the velocity of the fluid as it flows through a passage of a definite size, this velocity being indicated by a recording device. A third class of meters is that known as "proportional" meters. These meters measure a definite portion of the main stream by passing it through a measuring device, and by thus measuring a percentage of the total flow, the whole is known and recorded on the counter.

Each of these various classes of meters has advantages peculiar to itself, and no one class will meet the requirements of all kinds of service; therefore, they are each used largely for those conditions of service for which they are found to be the best adapted. The displacement type of meters may be divided into several classes. In one class the displacing member is a reciprocating piston, while in another the piston has a continuous or rotary motion; in another the piston has a motion of oscillation, and in another class the displacing member is a disc and has a motion called one of nutation.

The placing of meters on private fire service lines should be avoided if possible, where such lines are used exclusively for fire protection, as there is danger of interrupted service if a meter is installed with any mechanism whatever that will obstruct the free flow of the water. It is assumed that there will be no charge for water used for extinguishing fires; therefore, if the service is used for fire protection alone there is no necessity for installing a meter, unless the owner of the private fire service is suspected of using the water dishonestly. The illegitimate use of water through private fire lines appears to be the exception rather than the rule, and should be controlled by proper inspection.

Meter reading is the foundation of water bills and too much emphasis cannot be placed upon the importance of knowing that the meter readings are correct. Only familiarity with the work and with the appearance of the dials under various conditions of moisture, dirt, etc., will enable the meter reader to do his work accurately, and accuracy is of the greatest importance in meter reading.

Whenever possible or practical to do so a railroad should standardize its water meters, as by so doing employes are enabled to familiarize and perfect themselves in the knowledge of the mechanical construction which is necessary to maintain a system of meters at least expense, and greatest efficiency. It also permits of carrying a smaller stock of repair parts than would be the case where different types of meters were used.

Appendix E—Flue Failures Due to Improper Water Conditions

The operating efficiency of the modern locomotive is largely dependent upon the condition of its boiler, and to derive full service from the boiler it is necessary that water of such quality be used as will permit no liability of flue failures.

The arbitrary limit of time now allowed between flue renewals by the Federal boiler inspection regulations has

been raised from three to four years. This period is, at present, much longer than the ordinary life of flues, especially in the Central and Middle West territory. With the increase in size of power and the larger evaporating capacities per unit of heating surface with the greater water consumption, the flue failures caused by mineral and other agencies in the water have become more pronounced. Not only are the immediate effects of the failures serious with respect to the increased cost for boiler repairs and overtime to crews, but the intangible expense due to delays to traffic, immediate and en route, are considerable.

The most common failures experienced are those due to leaking. These are caused principally by scale collecting at the joints of the flues and the flue sheet and hardening while the metal is hot and expanded. Consequently when cooling takes place and the sheets contract, there will be no contraction in the hard scale and the joints are opened. Other failures which are becoming increasingly frequent of late are those due to pitting. These are usually the result of "scab-pitts" or local corrosion working through the metal in spots. As a rule they are not sufficiently serious to cause a complete failure on the line, but the expense of delays and inconvenience to traffic is considerable. In the case of water tube boilers at stationary plants the most common flue failure is the result of bagging and blowouts. This is usually caused by sludge or sediment settling into the lower rows of tubes, baking on the bottom section, and causing a mud burn or blowout through overheating of the metal.

In general, all waters contain similar substances in solution, although varying considerably in amounts and proportions. These are usually divided for identification purposes as incrusting and non-incrusting solids. In occasional instances from mine drainage regions, free acid waters may be found. At times surface supplies carry sufficient mud and suspended matter to cause trouble. In some waters the dissolved gases, usually carbon dioxide or oxygen, but occasionally hydrogen sulphide, demand attention. However, the common constituents of the incrusting solids, namely, the carbonates and sulphates of calcium and magnesium, are those responsible for the large majority of flue failures attributed to water conditions.

The scale formed on the flues is of considerably varying quality, depending upon the total amount of incrusting solids and the ratio of the component radicles, together with the rate of evaporation. It is known that if the incrusting sulphate content is high, especially with a large magnesium ratio, the scale formed will be, as a rule, hard and tenacious, and very destructive to the boiler. If, on the other hand, the predominate part is calcium carbonate, especially with slow evaporation, the scale will be soft and porous and more easily removed by mechanical means with less damage to the flues and boiler. A muddy water or one high in suspended matter causes trouble from baking and mud burning, but in cases of high mud and suspended matter the visible evidence of prospective trouble is continually present, urging suitable corrective steps of either filtration, sedimentation, or abandonment of the supply. High rate of evaporation will tend to bake any incrustants into a hard scale.

The cure of boiler troubles is, in a great measure, similar to the cure of diseases, in that each problem has a specific remedy and it is impossible to lay down general directions which will fit all cases. Boiler compounds of all natures have been exploited, some acting mechanically, others supposedly mechanically, while others are definitely chemical. A few manufacturers of boiler compounds have gone into the matter on a scientific and legitimate basis and have had considerable success in altering the scaling solids into loose non-crystalline, non-adhering sludge. However, except in exceptional instances, it is poor practice and uneconomical to make a sludge tank out of the boiler.

Where flue failures are common the water conditions should be thoroughly investigated, and it is a good general rule that at points where trouble originates the water should be properly softened and the objectionable constituents absolutely removed before the water is delivered to locomotives for steam purposes. At present prices it has been found that lime and soda ash are the least expensive chemicals which can be used to advantage, and with a water treating plant, properly operated, the harmful impurities can be precipitated and removed as sludge in the softener with a clear, soft, safe water delivered for steam purposes.

It has been found generally advisable to so adjust the treatment that a slight excess of hydrate alkalinity due to caustic soda be maintained in the boiler at all times. This precludes the formation of any hard sulphate scale; neutralizes any acid tendencies; assures absence of magnesium compounds due to the insolubility of magnesium hydrate; neutralizes carbon dioxide, and minimizes the effects of galvanic action.

Appendix F—Instructions for the Care of Water Stations

The committee presented a detailed set of instructions for the care of water stations. These were practically the same as those submitted last year and published in the daily edition of the *Railway Age* for March 20, 1918, page 634. They were followed by a series of examination questions on the care of boilers, internal combustion engines and electrically operated pumps.

Discussion

A. F. Dorley (Chairman): There is one paragraph in the Manual which the committee wishes to revise, and that is the section on "Foaming and Priming." The committee feels that the explanation of the phenomenon commonly called foaming, which causes so much trouble in locomotive boilers is not quite satisfactory, and there is a revision given under "Appendix A."

In addition to this, this section of the Manual is unsatisfactory, in that it does not differentiate between what is called "foaming" and "priming." I move, Mr. Chairman, that this revision of the Manual be adopted. (Motion carried.)

Mr. Dorley: The report on subject 3 will be found in Appendix C: "Design of impounding reservoirs and conditions under which they are economical."

The committee feels that there is great need of information on the subject of the design of reservoirs. There is a great amount of data available in the literature on the subject of rainfall and run-off and percolation and transpiration, and other factors that have to be considered in designing a reservoir, but the committee does not know of any definitely outlined method for assigning values for these various factors and an attempt is being made by the sub-committee, to work out such a method. This report is one of progress and we consider it a splendid start in that direction. We hope to have the report in final shape for next year.

Subject No. 4, "Plans and specifications for typical water station layouts," will be assigned during the coming year to the Committee on Yards and Terminals. This is a progress report also.

Subject No. 5 is simply a report of progress. The title of this subject is "Suitable types of meters for use in railroad water service, methods followed in testing

and reading meters, and checking the consumption of city water.

Subject No. 6 is: "Locomotive flue failures which may be due to improper water conditions and methods of treatment to correct such conditions." The committee feels that there is need of some information on this subject. As we all know, flue failures are becoming an increasingly troublesome and expensive part of locomotive maintenance. As a matter of fact, there is an epidemic of flue failures on practically all roads.

A part of these failures which really result in the reduced life of flues, is undoubtedly due to the change from the old style charcoal iron flue to the spellerized steel flue, which is now in use, part of it due to the higher steam pressure that is being carried in modern locomotives as compared with the lower pressure in smaller locomotives; but the committee is prepared to admit that a part of this reduced life is undoubtedly due to harmful and deleterious impurities in the water, and the present epidemic is probably due to these three causes combined. Mr. Bardwell, who has had charge of this sub-committee, has given us the chemistry of these flue failures, so far as they are due to water conditions.

The Chairman: If there is no objection, the report on subjects 2, 3, 4, 5 and 6 will be received as information, as a progress report.

Mr. Dorley: I move that the report on instructions for the care of water stations be inserted in the Manual.

(The motion was carried and the committee was dismissed with thanks.)

Report on Iron and Steel Structures

THE ASSOCIATION'S General Specifications for Steel Railway Bridges were adopted in 1906, and are printed in the Manual, pp. 482 to 505, inclusive. The Specifications for Erection were adopted in 1912 and are printed in the Manual, pp. 508 to 513, inclusive.

The revised specifications (Appendix A to this report) are submitted by the committee as a conclusion, to be printed in the Manual in place of the specifications referred to above.

The rules and unit stresses for classifying and rating the capacity of existing bridges are given in the Manual, pp. 506 and 507. The committee is not ready to report any changes, but expects to be able to report at the next convention revised rules for rating based upon the live load diagram used in the specifications and with details of unit stresses, impact, etc. The committee invites suggestions from the members of the association and others on this subject.

The committee has under observation some experimental applications of plastic compounds for the protection of structures of steel and concrete exposed to direct action of the blast from locomotive stacks, but has no report to make to this convention.

Specifications for movable bridges were submitted to the 1918 convention and printed in the Proceedings, Vol. 19, pp. 814 to 866, inclusive. The committee is engaged in a revision of these specifications and expects to submit them to the 1920 convention for adoption and printing in the Manual. The committee invites suggestions and criticisms of these specifications for movable bridges in order that the revision, when submitted to the convention, may be as satisfactory as possible.

The conclusions of the committee with reference to secondary stresses are embodied in the specifications. No experimental work on impact has been done during the past year and none is contemplated. The conclusions from the experimental work already done have been presented to the association from time to time, and the association has adopted an impact formula based upon them. The conclusions already reached have been based upon a large amount of experimental work, and are not likely to be modified by any further work of that kind which the committee might be able to do in the near future. The sub-committee on this subject has been discharged, effective with the presentation of this report to the convention, and the committee requests that this subject be discontinued by the Board of Direction.

On account of war conditions the committee has been unable to make any further tests on columns, and the committee requests the Board of Direction to continue the subject in order that further study may be made when the conditions will allow it.

A report on the principles for detailed design of flashing, drainage and reinforcement for waterproofing purposes is being worked upon by the sub-committee and is expected to be ready to present to the convention with the report of 1920.

In the report of the Committee on Yards and Terminals to the 1918 convention the Committee on Iron and Steel Structures was asked to approve the data of scale superstructures contained in Tables 1 and 2 on pp. 330 and 331 of the Proceedings, Vol. 19. These tables contain the data for designing and the resultant recommended girder section for weigh-bridge girders and transverse floor beams for track scales of three different standard sectional capacities.

After conference with the Yards and Terminals committee and careful study of the sections proposed, the committee approves the recommended sections.

RECOMMENDATIONS

The committee recommends:

1. That the Revision of the General Specifications for Steel Railway Bridges, be adopted and the Specifications, Appendix A, printed in the Manual.

2. That the approval of the sections for track scales, weigh-bridge girders, and transverse floor beams recommended by the Committee on Yards and Terminals be recorded in the Proceedings.

Committee: O. E. Selby (C. C. C. & St. L.), chairman; F. E. Turneaure (Univ. of Wis.), vice-chairman; F. Auryansen (L. I.), J. A. Bohland (G. & N.), W. S. Bouton (B. & O.), A. W. Carpenter (N. Y. C.), Charles Chandler (I. C.), J. E. Crawford (N. & W.), F. O. Dufour, W. R. Edwards (I. C. C.), A. Chas. Irwin, B. R. Leffler (N. Y. C.), W. H. Moore (N. Y. N. H. & H.), P. B. Motley (C. P. R.), C. D. Purdon (St. L. S. W.), Albert Reichmann (Am. Br. Co.), J. W. Reid, A. F. Robinson (A. T. & S. F.), H. N. Rodenbaugh (U. S. R. R. A.), H. B. Seaman (Cons. Engr.), C. E. Smith (Cons. Engr.), I. F. Stern (Cons. Engr.), H. B. Stuart (G. T.), G. E. Tebbetts, L. F. VanHagan (Univ. of Wis.), J. A. L. Waddell (Cons. Engr.), H. T. Welty (N. Y. C.).

Appendix A—General Specifications for Steel Railway Bridges

(For Fixed Spans Less Than 300 Ft. in Length.)

1919

PROPOSALS AND DRAWINGS

1. **Definitions of Terms.** The term "Engineer" refers to the Chief Engineer of the Company or his subordinates in

authority. The term "Inspector" refers to the inspector or inspectors representing the Company. The term "Company" refers to the Railway Company or Railroad Company party to the contract. The term "Contractor" refers to the manufacturing or fabricating contractor party to the contract. The term "Erector" refers to the erecting contractor party to the contract.

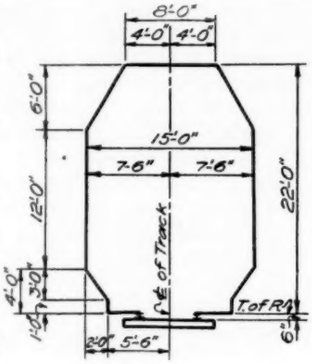


Fig. 1

2. **Proposals.** Bidders shall submit proposals to conform with the terms in the letter of invitation. The proposals preferably shall be based upon plans and specifications furnished by the Company showing the general dimensions necessary for designing the structure, the stresses and the general or typical details. Invitations covering work to be erected by the Contractor shall state the general conditions at the site, such as character of foundations, traffic conditions, etc.

3. **Drawings to Govern.** Where the drawings and the specifications differ, the drawings shall govern.

4. **Patented Devices.** The Contractor shall protect the Company against claims on account of patented devices or parts.

5. **Drawings.** After the contract has been awarded and before any shop work is commenced, the Contractor shall submit to the Engineer for approval duplicate prints of stress sheets and shop drawings, unless such drawings shall have been prepared by the Company. The tracings of these drawings shall be the property of and be delivered to the Company after the completion of the contract. Shop drawings shall be made on the dull side of the tracing cloth, 24 by 36 in. in size, including margins. The margin at the left end shall be 1½ in. wide, and the others ½-in. The title shall be in the lower right-hand corner. No changes shall be made on any approved drawing without the consent, in writing, of the Engineer.

6. The Contractor shall be responsible for the correctness of his drawings, and for shop fits and field connections, although the drawings may have been approved by the Engineer.

7. Any material ordered by the Contractor prior to the approval of the drawings shall be at his risk.

General Features of Design

8. **Materials Used.** Structures shall be made wholly of structural steel except where otherwise specified. Cast steel may be used for shoes and bearings. Cast iron may be used only where specifically authorized by the Engineer.

9. **Types of Bridges.** The different types of bridges may be used as follows:

Rolled beams for spans up to 35 feet.
Plate girders for spans from 30 feet to 125 feet.
Riveted trusses for spans from 100 feet to 300 feet.
Pin-connected trusses for spans from 150 feet to 300 feet.

10. **Number of Trusses.** Unless otherwise specified, double-track through bridges shall have only two trusses or girders, and four-track bridges three.

11. **Dimensions for Calculation.** The dimensions for the calculation of stresses shall be as follows:

Span Length

For trusses and girders, the distance center to center of end bearings.

For floor beams, the distance center to center of trusses or girders.

For stringers, the distance center to center of floor beams.

Depth

For riveted trusses, the distance between centers of gravity of chord sections.

For pin-connected trusses, the distance center to center of chord pins.

For plate girders, floor beams and stringers, the distance between centers of gravity of flanges, but not to exceed the distance back to back of the flange angles.

12. **Spacing of Trusses, Girders and Floorbeams.** The width center to center of girders or trusses shall not be less than one-twentieth of the effective span, and not less than is necessary to prevent overturning under the assumed lateral loading. Panel lengths shall not exceed 1½ times the width c. to c. of trusses or girders.

13. **Clearances.** If the alinement is straight, clearances shall be not less than shown on the diagram, Fig. 1. If the alinement is curved, the width of the diagram shall be increased so as to provide the same minimum clearances for a car 80 ft. long, 14 ft. high and 60 ft. center to center of trucks, allowance being made for curvature and superelevation of rails. The height of rail shall be assumed as 6 in.

14. **Deck Spans on Curves.** Deck spans on curves shall have the center line of the span placed, usually, so as to bisect the middle ordinate of and be parallel with the chord of the curve.

15. **Skew Bridges.** In skew bridges without ballasted floors, the backwalls for each track shall be square with the track.

16. **Ambiguity of Stress.** Structures shall be designed so as to avoid, as far as practicable, ambiguity in the determination of the stresses.

Loads

17. **Loads.** The structures shall be proportioned for the following loads:

a. The dead load.
b. The live load.
c. The lateral load.

Stresses due to these loads, as hereinafter specified, shall be shown separately on the stress sheets.

18. Members shall be proportioned for that combination of stresses which gives the maximum total stress, except as otherwise provided.

19. **Dead Load.** The dead load shall consist of the estimated weight of the entire suspended structure. Timber shall be assumed to weigh 4½ lb. per foot B. M., ballast 120 lb. per cu. ft., reinforced concrete 150 lb. per cu. ft., waterproofing 150 lb. per cu. ft., and rails and fastenings 150 lb. per linear foot of track. If ballast is used, it shall be assumed level with the base of rail and the weight of ties neglected.

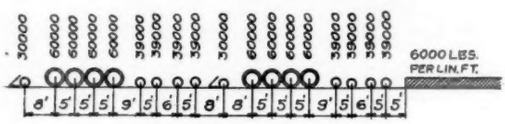


Fig. 2

Fig. 3

20. **Live Load.** The minimum live load for each track shall be as shown in Figs. 2 and 3.

The loading that gives the larger stresses shall be used.

21. **Heavier Loading.** Heavier loadings shall be proportional to the specified minimum loadings with the same wheel spacing.

22. In calculating the maximum stresses due to live load and centrifugal force when two, three or four tracks are simultaneously loaded, use the following percentages of the specified live load:

For two tracks loaded, 95 per cent.
For three tracks loaded, 90 per cent.
For four tracks loaded, 85 per cent.

23. **Floors.** Wooden ties shall be designed for the maximum wheel load specified distributed over three ties and with 100 per cent impact added. The fiber stress shall not exceed 2,000 lb. per sq. in. Wooden tie floors shall be secured to the stringers or girders. The ties shall be not less than 10 ft. in length. They shall be placed with openings not to exceed 4 in. in width and shall be secured against bunching. The maximum dap of ties shall be 1½ in.

24. Floors consisting of beams transverse to the axis of the structure shall be designed for a uniform live load of 15,000 lb. per linear foot for each track, when the minimum live load specified is used. When heavier loadings are used, this uniform load shall be increased proportionately. Floors consisting of longitudinal beams shall be designed for the wheel loads specified.

25. In ballasted floor bridges, the live load shall be considered as uniformly distributed laterally over a width of 10 ft.

26. Ballasted floors shall have at least 6 in. of ballast under the ties.

27. **Reduced Dead Load for Solid Floors.** In bridges with ballasted floors, only three-fourths of the computed dead weight of the floors shall be considered.

28. **Impact.** The dynamic increment of the live load shall be added to the maximum computed live load stresses and shall be determined by the formula,

$$I = S\frac{300}{300 + \frac{L^2}{100}}, \text{ in which}$$

I = impact or dynamic increment to be added to the live-load stress.

S = computed maximum live-load stress.

L = the following values in feet:

a. For spans, the distance center to center of end bearings.

b. For stringers, the distance center to center of floor beams.

c. For hip verticals and similar suspenders, floor beams, and transverse girders and their supports, the sum of the adjacent panel or span lengths.

d. For floors with transverse beams, zero.

29. For bridges designed exclusively for electric locomotives, the impact stresses shall be taken as one-half of those given by the formula in paragraph 28.

30. Impact shall not be added to stresses produced by longitudinal or lateral forces.

31. **Eccentricity of Load on Curves.** For bridges on curves, provision shall be made for the increased load carried by any truss, girder or stringer due to the eccentricity of the load.

32. **Lateral Forces.** The lateral force shall consist of a moving load equal to 30 lb. per sq. ft. on 1½ times the vertical projection of the structure on a plane parallel with its axis (but never less than 200 lb. per linear foot at the loaded chord, and 150 lb. per linear foot at the unloaded chord), and a moving load of 600 lb. per linear foot applied 8 ft. above the base of rail.

33. In calculating the stresses in viaduct towers due to lateral force, the viaduct shall be considered as loaded on either one or both tracks, with empty cars weighing 1,200 lb. per linear foot.

34. If a moving load of 50 lb. per square foot on 1½ times the vertical projection of the unloaded structure on a plane parallel with its axis produces greater stresses than the lateral force defined in paragraph 32, it shall be provided for.

35. The bracing between chords or flanges shall be capable of resisting a transverse shear in any panel equal to 2 per cent of the total axial stress in the two chords in that panel.

36. **Centrifugal Force.** On curves, the centrifugal force (assumed to act 6 ft. above the rail) shall be taken equal to a percentage of the live load according to the following table:

Degree of Curve..	0° 20′	0° 40′	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	11°	12°
Percentage of live load.....	2½	5	7½	10	10	10	10	10	10	10	10	10	10	10
Speed in miles per hour.....	80	80	80	65	53	46	41	38	35	33	31	29	28	27

37. **Longitudinal Force.** Provision shall be made in the design for the effect of a longitudinal force of 20 per cent of the live load on one track only, applied 6 ft. above the top of the rail. Where, by reason of continuity of members or frictional resistance, the longitudinal force will be largely absorbed before it reaches supporting members, its effect on such members shall be taken as one-half that specified above.

38. **Applications of Live Load.** The stresses shall be shown for the following applications of the live load:

a. As a dynamic load acting vertically, the static stresses and the dynamic increments or impact stresses being shown separately and designated as the live-load static stresses and the live-load impact stresses respectively.

b. As a state longitudinal force, due to tractive effort or braking, the stresses being designated as longitudinal force stresses.

c. As a lateral force on curves, the stresses being shown separately for this force acting as a static load and designated as the centrifugal force stresses.

Unit Stresses and Proportioning of Parts

39. The several parts of structures shall be so proportioned that the unit stresses will not exceed the following, except as modified in paragraphs 47 and 48:

	Pounds per sq. inch
Axial tension, net section	16,000
Axial compression, gross section. l = the length of the member in inches.. r = the least radius of gyration of the member in inches.	$13{,}000 - \frac{1}{4}\left(\frac{l}{r}\right)^2$
Tension in extreme fibers of rolled shapes, built sections and girders, net section	16,000
Tension in extreme fibers of pins	24,000
Shear in plate girder webs, gross section	10,000
Shear in power-driven rivets and pins	12,000
Bearing on power-driven rivets, pins, outstanding legs of stiffner angles, and other steel parts in contact	24,000
The above mentioned values for shear and bearing shall be reduced 25 per cent for countersunk rivets, hand-driven rivets, floor-connection rivets, and turned bolts.	
Bearing on expansion rollers, per linear inch. d = the diameter of rollers in inches.	$600d$

	Pounds per sq. inch
Bearing on granite masonry	800
Bearing on sandstone and limestone masonry	400
Bearing on concrete masonry	600

40. For cast steel in shoes and bearings, the above mentioned unit stresses shall apply.

41. The diagonal tension in webs of girders and rolled beams at sections where maximum shear and bending occur simultaneously, shall not exceed 16,000 lb. per square inch.

42. **Effective Bearing Area.** The effective bearing area of a pin, a bolt or a rivet shall be its diameter multiplied by the thickness of the piece, except that for countersunk rivets half the depth of the countersink shall be omitted.

43. **Effective Diameter of Rivets.** In proportioning rivets, the nominal diameter of the rivet shall be used.

44. **Reversal of Stress.** Members subject to reversal of stress under the passage of the live load shall be proportioned as follows:

Determine the resultant tensile stress and the resultant compressive stress and increase each by 50 per cent of the smaller; then proportion the member so that it will be capable of resisting either increased resultant stress. The connections shall be proportioned for the sum of the resultant stresses.

45. **Stresses in Web Members.** In proportioning web members of trusses, use two-thirds of the dead load stress plus one and one-sixth times the live load stress, including impact, where this sum is greater than the sum of the dead load stress and the live load stress, including impact.

46. **Combined Stresses.** Members subject to both axial and bending stresses (including bending due to floor beam deflection) shall be proportioned so that the combined fiber stresses will not exceed the allowed axial stress. In members continuous over panel points, only three-fourths of the bending stress computed as for simple beams shall be added to the axial stress.

47. Members subject to stresses produced by a combination of dead load, live load, impact and centrifugal force, with either lateral or longitudinal forces, or bending due to lateral action, may be proportioned for unit stresses 25 per cent greater than those specified in paragraph 39; but the section shall not be less than that required for dead load, live load, impact and centrifugal force.

48. **Secondary Stresses.** Designing and detailing shall be done so as to avoid secondary stresses as far as possible. In ordinary trusses without subpanelling, no account usually need be taken of the secondary stresses in any member whose width measured in the plane of the truss is less than one-tenth of its length. Where this ratio is exceeded, or where subpanelling is used, secondary stresses due to deflection of the truss shall be computed. The specified unit stresses may be increased one-third for a combination of the secondary stresses with the axial stresses.

49. **Compression Flanges.** The gross area of the compression flanges of plate girders shall not be less than the gross area of the tension flanges, but the stress per square inch shall not exceed

$$14{,}000 - 200\frac{l}{b}, \text{ in which}$$

l = the length of the unsupported flange, between lateral connections or knee braces.

b = the flange width.

Details of Design

50. **Limiting Lengths of Members.** The ratio of length to least radius of gyration shall not exceed 100 for main compression members nor 120 for wind and sway bracing.

51. The lengths of riveted tension members shall not exceed 200 times their least radius of gyration.

52. **Depth Ratios.** The depth of trusses preferably shall be not less than one-tenth of the span. The depth of plate girders preferably shall be not less than one-twelfth of the span. The depth of rolled beams used as girders and the depth of solid floors preferably shall be not less than one-fifteenth of the span.

53. **Parts Accessible.** Details shall be designed so that all parts will be accessible for inspection, cleaning and painting. Closed sections shall be avoided wherever possible.

54. **Pockets.** Pockets or depressions which would hold water shall have efficient drain holes, or shall be filled with concrete.

55. **Eccentric Connections.** Members shall be connected so that their gravity axes will intersect in a point. Eccentric connections shall be avoided if practicable, but, if unavoidable, the members shall be proportioned to resist the additional stresses so produced.

56. **Counters.** Riveted counters are preferred. If counters are subject to reversal of stress, their end connections preferably shall be riveted. Adjustable counters shall have open turnbuckles.

57. **Strength of Connections.** Connections shall have a strength at least equal to that of the members connected, regardless of the computed stress. Connections shall be made, as nearly as practicable, symmetrical about the axis of the members.

58. **Limiting Thickness of Metal.** Metal shall not be less than 3/8-inch thick, except for fillers. Metal subject to marked corrosive influences shall be increased in thickness or protected against such influences.

59. **Effective Area of Angles.** The effective area of single angles in tension shall be assumed as the net area of the connected leg plus 50 per cent of the area of the unconnected leg. The effective area of double angle members connected by both legs shall be assumed as 90 per cent of the net area of the angles. Single angles connected by lug angles shall be considered as connected by one leg.

60. **Sizes of Rivets.** Rivets shall be 7/8-in. in diameter unless otherwise specified.

61. **Pitch of Rivets.** The minimum distance between centers of rivet holes shall be three diameters of the rivet, but the distance preferably shall be not less than 3½-in. for 1-in. rivets, 3 in. for 7/8-in. rivets and 2½ in. for ¾-in rivets. The maximum pitch in the line of stress for members composed of plates and shapes shall be 7 in. for 1 in. rivets, 6 in. for 7/8-in. rivets and 5 in. for ¾-in. rivets. For angles with two gage lines and rivets staggered, the maximum pitch in each line shall be twice the amounts given above. If two or more web plates are used in contact, stitch rivets 12 in. in gage and pitch shall be provided to make them act in unison. In tension members composed of two angles in contact, a pitch of 12 in. may be used for riveting the angles together.

62. **Edge Distance.** The minimum distance from the center of any rivet hole to a sheared edge shall be: 1¾ in. for 1 in. rivets, 1½ in. for 7/8-in. rivets and 1¼ in. for ¾-in. rivets; to a rolled edge 1½ in., 1¼ in. and 1⅛ in., respectively. The maximum distance from any edge shall be eight times the thickness of the plate, but shall not exceed 6 in.

63. **Size of Rivets in Angles.** The diameter of the rivets in any angle whose size is determined by calculated stress shall not exceed one-fourth of the width of the leg in which they are driven. In angles whose size is not so determined 1 in. rivets may be used in 3½ in. legs, 7/8-in. rivets in 3 in. legs, and ¾-in. rivets in 2½ in. legs.

64. **Long Rivets.** Rivets which carry calculated stress and whose grip exceeds four diameters shall be increased in number at least one per cent for each additional 1/16-in. of grip. If the grip exceeds six times the diameter of the rivet, specially designed rivets shall be used.

65. **Pitch of Rivets at Ends.** The pitch of rivets at the ends of built compression members shall not exceed four diameters of the rivet for a distance equal to one and one-half times the maximum width of the member.

66. **Compression Members.** In built compression members, the metal shall be concentrated in the webs and flanges. The thickness of each web shall be not less than one-thirtieth of the distance between the lines of rivets connecting it to the flanges. The thickness of cover plates shall be not less than one-fortieth of the distance between the nearest rivet lines.

67. **Outstanding Legs of Angles.** The width of the outstanding legs of angles in compression (except when reinforced by plates) shall not exceed the following:

a. For stringer flange angles, ten times the thickness.

b. For main members carrying axial stress, twelve times the thickness.

c. For bracing and other secondary members, fourteen times the thickness.

68. **Stay Plates.** The open sides of compression members shall be provided with lacing bars and shall have stay plates as near each end as practicable. Stay plates shall be provided at intermediate points where the lacing is interrupted. In main members, the length of the stay plates shall be not less than 1¼ times the distance between the nearest lines of rivets connecting them to the flanges, and the length of intermediate stay plates shall be not less than three-quarters of that distance. Their thickness shall be not less than one-fiftieth of the same distance.

69. Tension members composed of shapes shall have their separate segments stayed together. The stay plates shall have a length not less than two-thirds of the lengths specified for stay plates on compression members.

70. **Lacing.** The lacing of compression members shall be proportioned to resist a shearing stress of 2 per cent of the direct stress. The minimum width of lacing bars shall be 3 in. for 1 in. rivets, 2¾ in. for 7/8-in. rivets, 2½ in. for ¾-in. rivets, and 2 in. for 5/8-in. rivets. The thickness shall be made as required by paragraph 39, in which "l" shall be taken as the distance between connections to the main sections.

71. In members composed of side segments and a cover plate, with the open side laced, one-half the shear shall be considered as taken by the lacing. Where double lacing is used, the shear in the plane of the lacing shall be equally distributed between the two systems.

72. In connecting lacing bars to flanges, 5/8-in. rivets shall be used for flanges less than 2½ in. wide, ¾-in. rivets for flanges from 2½ to 3½ in. wide, and 7/8-in. rivets for flanges 3½ or more in. wide. Lacing bars with at least two rivets in each end shall be used for flanges over 5 in. wide.

73. The angle of lacing bars with the axis of the member shall be not less than 45 deg. for double lacing, and 60 deg. for single lacing. If the distance between rivet lines in the flanges is more than 15 in. and a single rivet bar is used, the lacing shall be double and riveted at the intersections.

74. Lacing bars shall be so spaced that the $\frac{l}{r}$ of the portion of the flange included between their connections will be not greater than 40.

75. **Splices.** Abutting joints in compression members faced for bearing shall be splied on four sides. The gross area of the splice material shall be not less than 50 per cent of the gross area of the member.

76. Joints in riveted work not faced for bearing, whether in tension or compression, shall be fully spliced.

77. **Net Section at Pins.** In riveted tension members in pin-connected trusses, the net section across the pin hole shall be 135 per cent and the net section back of the pin hole 100 per cent of the net section of the body of the member, and there shall be sufficient rivets to make the material effective.

78. **Net Section Defined.** The net section of riveted members shall be the least area which can be obtained by deducting from the gross sectional area the areas of holes cut by any plane perpendicular to the axis of the member and parts of the areas of other holes on one side of the plane within a distance of 4 in., which are on gage lines 1 in. or more from those of the holes cut by the plane, the parts being determined by the formula:

$$A\left[1-\frac{P}{4}\right], \text{ in which}$$

A = the area of the hole.

P = the distance in inches of the center of the hole from the plane.

79. In determining the net section, the diameter of the rivet hole shall be taken 1/8 in. larger than the nominal diameter of the rivet.

80. **Pin Plates.** Where necessary to give the required section or bearing area, pin holes shall be reinforced on both sides of each segment by plates, one of which on each side must be as wide as the outstanding flanges will permit. These plates shall contain enough rivets to transmit and distribute the bearing pressure uniformly over the full cross section. At least one full-width plate on each segment shall extend to the far edge of the stay plate and the others not less than 6 in. beyond the near edge.

81. **Indirect Splices.** If splice plates are not in direct contact with the parts which they connect, rivets shall be used on each side of the joint in excess of the number required in the case of direct contact to the extent of two extra lines for each intervening plate.

82. **Fillers.** Where rivets carrying stress pass through fillers, the fillers shall be extended beyond the connected member and the extension scured by additional rivets sufficient to develop the value of the filler.

83. **Forked Ends.** Forked ends on compression members will be permitted only where unavoidable. Where forked ends are used, a sufficient number of pin plates shall be provided to make the jaws of twice the sectional area of the member and they shall be extended as far as necessary in order to carry the stress of the main member into the jaws, but shall not be shorter than required by paragraph 80.

84. **Pins.** Pins shall be long enough to secure a full bearings of all parts connected upon the turned body of the pin. They shall be secured by chambered nuts or be provided with washers if solid nuts are used. The screw ends shall be long enough to admit of burring the threads.

85. Pin connected members shall be held against lateral movement on the pins.

86. **Bolts.** Where members are connected by bolts, the turned bodies of the bolts shall be long enough to extend through the metal. A washer at least ¼ in. thick shall be used under the nut. Bolts shall not be used except by special permission.

87. **Upset Ends.** Bars with screw ends shall be upset so that the area at the root of the thread will be at least 15 per cent larger than in the body of the bar.

88. **Sleeve Nuts.** Sleeve nuts shall not be used.

89. **Expansion.** Provision shall be made for expansion and contraction at the rate of 1 in. for every 100 ft. in length. The expansion ends shall be secured against lateral movement. In spans over 250 ft. in length, provision shall be made for expansion in the floor.

90. **Expansion Bearings.** Spans 70 ft. or more in length shall have turned rollers or rockers at one end. Spans of less length shall be arranged to slide on smooth surfaces. Expansion bearings shall be designed to permit longitudinal motion only.

91. **Fixed Bearings.** Fixed bearings shall be firmly anchored to the supports.

92. **Rollers.** Expansion rollers shall be not less than 6 in. in diameter. They shall be coupled together with substantial side bars, which shall be so arranged that the rollers can be cleaned readily. Rollers shall be geared to the upper and lower plates.

93. **Pedestals and Shoes.** Pedestals and shoes shall be made of plates and angles, or cast steel. The difference between the top and bottom bearing widths shall not exceed twice the depth. For hinged bearings, the depth shall be measured from the center of the pin. The web plates and the angles connecting them to the base plate shall be not less than ¾ in. thick. If the size of the pedestal permits, the webs shall be rigidly connected transversely. The minimum thickness of the metal in cast steel pedestals shall be 1 in. Pedestals and shoes shall be so constructed that the load will be distributed uniformly over the entire bearing. Spans 70 ft. or more in length shall have hinged bearings at each end.

94. **Inclined Bearings.** For spans on an inclined grade and without hinged bearings the sole or masonry plates shall be beveled so that the masonry surfaces will be level.

95. **Name Plates.** There shall be a name plate, showing in raised letters and figures the name of the manufacturer and the year of construction, bolted to the bridge near each end at a point convenient for inspection.

Floors

96. **Types of Floors.** The floors may consist of steel floor-beams and stringers, with timber cross-ties supporting the rails, or of one of the solid floor types with ballast.

97. **Floor Members.** Floor members shall be designed with special reference to stiffness, and the depth of floor-beams and stringers shall, as a rule, be not less than one-eighth of their length.

98. Specifications for plate girders shall also apply to floor-beams and stringers.

99. **Spacing of Stringers.** Stringers usually shall be spaced 6 ft. 6 in. center to center. If four stringers are used under one track, each pair shall be spaced symmetrically about the rail.

100. **Stop Angles.** Stringers which frame into floor-beams shall have an angle riveted to the top flange at each end to space the end ties at least 1 in. from the flanges of the floor-beams.

101. **1-Beam Girders.** Rolled beams supporting timber decks shall be arranged with not less than two nor more than four beams under each rail. The beams in each group shall be placed symmetrically about the rail, and shall be spaced sufficiently far apart to permit cleaning and painting. They shall be connected by solid web diaphragms near the ends and at intermediate points, spaced not over twelve times the flange width. Bearing plates shall be continuous under each group of beams. End stiffeners shall be used if required by the provisions of paragraph 39.

102. **Floor-Beam Connections.** Floor-beams preferably shall be square to the girders or trusses. They shall be riveted directly to the girders or between the posts of through and deck truss spans. End floor-beams shall be used in square end bridges.

103. **End Connection Angles.** The legs of stringer connection angles shall be not less than 4 in. in width, and not less than ⅝ in. in thickness. Shelf angles shall be provided to support the stringers during erection, but the connection angles shall be sufficient to carry the whole load. Stringers preferably shall be riveted between the floor-beams. Rivets in connection angles shall be spaced closer at the bottom of the angles than at the top.

104. **Stringer Frames.** Where two lines of stringers are used under each track in panels more than 30 ft. in length, they shall be connected by cross frames.

105. **Solid Floor Connections.** Solid floors shall be connected to the girders or trusses by angles not less than ½ in. thick; one angle on each side of the web of I-beams and one on each of the vertical members of troughs.

106. **Proportioning Solid Floors.** Solid floors shall be proportioned by the moments of inertia of the sections, using the net areas of the component parts.

Bracing

107. **Design of Bracing.** Lateral, longitudinal and transverse bracing shall be composed of shapes with riveted connections. Lateral bracing shall have concentric connections to chords at end joints, and preferably throughout. The connections between the lateral bracing and the chords shall be designed to avoid, as far as practicable, any bending stress in the truss members.

108. When a double system of bracing is used, both systems may be considered simultaneously effective if the members meet the requirements, both as tension and compression members.

109. **Lateral Bracing.** Bottom lateral bracing shall be provided in all bridges except deck plate girder spans less than 70 ft. long from which it may be omitted.

110. Top lateral bracing shall be provided in deck spans and in through spans having sufficient head room.

111. **Portal and Sway Bracing.** Deck truss spans shall have vertical sway bracing at each panel point. They shall also have bracing in the planes of the end posts, proportioned to transfer the end reaction of the top lateral system to the masonry.

112. Through truss spans shall have portal bracing, with knee braces, as deep as the specified clearance will allow.

113. Through truss spans shall have sway bracing at each intermediate panel point if the height of the trusses is such as to permit of a depth of 6 ft. or more for the bracing. When the height of the trusses will not permit of such depth, the top lateral struts shall be of the same depth as the chord and shall have knee braces.

114. **Cross-Frames.** Deck plate girder spans shall be provided with cross-frames at each end proportioned to resist centrifugal and lateral forces, and shall have intermediate cross-frames at intervals not exceeding 18 ft.

115. **Laterals.** The smallest angle to be used in lateral bracing shall be 3½ by 3 by ⅜ in. There shall be not less than three rivets at each end connection of the angles. Angles shall be connected at their intersection by plates.

116. **Clearance.** Lateral bracing beneath the track shall be low enough to clear the ties.

117. **Tower Struts.** The struts at the base of viaduct towers shall be strong enough to slide the movable shoes when the track is unloaded.

Plate Girders

118. **Spacing of Girders.** The girders of deck bridges shall be spaced 6 ft. 6 in. between centers, except that:

a. In single-track deck spans 75 or more ft. in length, the girders shall be spaced in accordance with paragraph 12, but not less than 7 ft. 6 in. between centers.

b. In bridges on curves, the girders shall be spaced as shown on the plans.

119. **Design of Plate Girders.** Plate girders shall be proportioned either by the moment of inertia of their net section including compression side; or by assuming that the flanges are concentrated at their centers of gravity. In the latter case, one-eighth of the gross section of the web, if properly spliced, may be used as flange section.

120. **Flange Sections.** The flange angles shall form as large a part of the gross area of the flange as practicable. Side plates shall not be used except when flange angles exceeding 1 in. in thickness otherwise would be required.

121. Flange plates shall be equal in thickness to the flange angles or shall diminish in thickness from the flange angles outward. No plate shall have a thickness greater than that of the flange angles.

122. Where flange cover plates are used, one cover plate of the top flange shall extend the full length of each girder. Other flange plates shall extend at least 18 in. beyond the theoretical end.

123. **Thickness of Web Plates.** The thickness of web plates shall be not less than $\frac{1}{20}\sqrt{D}$, where "D" represents the distance between flanges in inches.

124. **Flange Rivets.** The flanges of plate girders shall be connected to the web with a sufficient number of rivets to transfer to the flange section the horizontal shear at any point combined with any load that is applied directly on the flange. One wheel load, where ties rest on the flange, shall be assumed to be distributed over 3 ft.

125. **Flange Splices.** Splices in flange members shall not be used except by special permission of the Engineer. Two members shall not be spliced at the same cross-section and, if practicable, splices shall be located at points where there is an excess of section. The net section of the splice shall exceed by 10 per cent the net section of the member spliced. Flange angle splices shall consist of two angles, one on each side.

126. **Web Splices.** Web plates shall be symmetrically spliced by plates on each side. The splice plates for shear shall be the full depth of the girders between flange angles. The splice shall be equal to the web in strength in both shear and moment. There shall be not less than two rows of rivets, staggered, on each side of the joint.

127. **End Stiffeners.** Plate girders shall have stiffener angles over end bearings, the outstanding legs of which will extend as nearly as practicable to the outer edge of the flange angles. These end stiffeners shall be proportioned for bearing on the flange angles, and shall be arranged to transmit the end reaction to the pedestals or distribute it over the masonry bearings. They shall be connected to the web by enough rivets to transmit the reaction. End stiffeners shall not be crimped.

128. **Intermediate Stiffeners.** The webs of plate girders shall be stiffened by angles at intervals not greater than:

(a) Six feet.

(b) The depth of the web.

(c) The distance given by the formula.

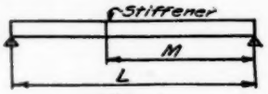


Fig. 4

$$d = 50t\,[6 - k\,(4k + 1)],$$ in which

d = the distance between rivet lines of stiffeners in in.

t = the thickness of the web in inches.

k = the ratio $\frac{M}{L}$, shown in Fig. 4, but never less than 0.5.

129. For girders in which the load is applied to the girders at floor-panel points, the stiffener intervals in any panel shall be uniform and based on the value of "k" at the end of the panel toward the nearer support.

130. If the depth of the web between the flange angles or side plates is less than 50 times the thickness of the web, intermediate stiffeners may be omitted.

131. Stiffener angles shall be placed at points of concentrated loading. Such angles shall not be crimped.

132. Intermediate stiffeners shall be riveted in pairs to the web of the girder. The outstanding leg of each angle shall not be less than 2 in. plus one-thirtieth of the depth of the girder, nor more than 14 times its thickness.

133. **Gusset Plates in Through Girders.** In through plate girder spans, the top flanges shall be braced by means of gusset plates or knee braces with solid webs connected to the floor-beams and extending usually to the clearance line. If the unsupported length of the inclined edge of the gusset plate exceeds 18 in. the gusset plate shall have one or two stiffening angles riveted along its edge. The gusset plate shall be riveted to a stiffener angle on the girder. Preferably it shall form no part of the floor-beam web.

134. In through plate girder spans with solid floors there shall be knee-braces with ⅜-in. webs, extending usually to the clearance line, at intervals of about 12 ft. Each knee-brace shall be well riveted to the floor and the girder, especially at the top, and shall have its edge reinforced by one or two angles.

135. **Ends of Through Girders.** If through plate girders project two feet or more above the base of the rail, the upper corners shall be rounded to a radius of about one-third of the depth of the girder, but not less than 18 in., the radius to be a multiple of 6 in. In multiple span bridges only the extreme ends shall be rounded. If adjacent spans have different depths and the difference in depth does not exceed 18 in., the top flanges of the deeper girders shall be curved at the ends to a radius equal to one and one-half times the depth of the girder, so that the depth of the ends will be the same as that of the adjacent girders. If the difference exceeds 18 in., the corners of the higher girders shall be rounded to a radius not greater than the difference in depth and not greater than one-third of the depth of the deeper girder. Exposed ends of through girders shall be neatly finished with end plates.

136. **Spans Shipped Riveted.** Deck plate girder spans less than 50 ft. in length shall be shipped riveted complete, unless otherwise specified.

137. **Central Bearings.** Plate girders 50 ft. or more in length shall be designed with central bearings.

138. **Masonry Bearings.** End bearings on masonry shall preferably be raised above the coping by metal pedestals.

139. Sole plates shall be not less than ¾ in. thick and not less in thickness than the flange angles plus ⅛ in.

140. **Anchor Bolts.** Anchor bolts shall be 1¼ in. in diameter and shall extend 12 in. into the masonry. There shall be washers under the nuts. Anchor bolt holes in pedestals and sole plates shall be 1⅝ in. in diameter, except that at expansion points the holes in the sole plates shall be slotted.

Trusses

141. **Type of Truss and Sections of Members.** Trusses shall have single intersection web systems and, preferably, inclined end posts. The top chords and end posts shall be made usually of two side segments with one cover plate and with stay plates and lacing on the open side. The bottom chords of riveted trusses shall be symmetrically made, usually of vertical side plates with flange angles. Web members shall be made of symmetrical sections. In pin-connected trusses, the tension chords shall be non-continuous for bending at pin joints.

142. **Camber.** The length of members of truss spans shall be such that the camber will be equal to the deflection produced by the combined dead and static live loads.

143. **Riveted Members in Pin-Connected Trusses.** Hip verticals (and members performing similar functions) and the two end panels of the bottom chords of pin-connected trusses shall be riveted members.

144. **Eye-Bars.** The cross sectional area of the head through the center of the pin hole shall exceed that of the body of the eye-bar by at least 40 per cent. The thickness of the bar shall be not less than one-eighth of the width nor less than 1 in., and not greater than 2½ in. The form of the head shall be submitted to the Engineer for approval before the bars are made. The diameter of the pin shall be not less than seven-eighths of the width of the widest bar attached.

145. **Packing.** The eye-bars of a set shall be packed symmetrically about the plane of the truss and as nearly parallel as practicable, but in no case shall the inclination of any bar to the plane of the truss exceed 1-16 in. per foot. They shall be packed as closely as practicable and arranged so as to produce the least bending moment on the pin. They shall be held against lateral movement, and arranged so that adjacent bars in the same panel will not be in contact.

146. **Gusset Plates.** The thickness of gusset plates connecting the various members of the truss shall be proportionate to the stress to be transferred, but shall not be less than ½ in.

147. **Facilities for Jacking.** The end pins of trusses shall project a sufficient distance outside of the faces of the chords to permit making attachments for jacking the span.

148. **Masonry Plates.** Masonry plates shall not be less than 1 in. thick.

Viaducts

149. **Type of Viaduct.** Viaducts shall consist usually of alternate tower spans and free spans of plate girders or

riveted trusses supported on bents. The tower spans usually shall be not less than 30 ft. long.

150. **Bents and Towers.** Viaduct bents shall be composed preferably of two supporting columns, and the bents usually shall be united in pairs to form towers. Towers shall be braced, both transversely and longitudinally, with riveted members. In double track towers, riveted diagonal bracing in a horizontal plane shall be used at the top.

151. **Single Bents.** Single bents shall have hinged ends, or else have their columns proportioned to resist the bending stresses produced by changes in temperature.

152. **Bottom Struts.** The bottom struts of viaduct towers shall be proportioned for the calculated stresses, but in no case for less than one-fourth of the dead load reaction on one pedestal.

153. **Batter.** The columns usually shall have a batter transversely of one horizontal to six vertical for single track viaducts, or one horizontal to eight vertical for double track viaducts.

154. **Spacing of Girders.** In single track viaducts, the girder spacing usually shall be uniform throughout, and shall be determined by the spacing for the longest span in the viaduct, according to the rules specified for deck plate girder spans.

155. In double track viaducts, the girders under each track shall be spaced 6 ft. 6 in. between centers, and the inner lines of girders shall be supported by cross-girders framed between and riveted to the posts.

156. **Girder Connections and Bracing.** Girders of tower spans shall be riveted at each end to the tops of the posts or cross-girders. Girders between towers shall have one end riveted, and shall be provided with an efficient expansion joint at the other end. No bracing or sway frame shall be common to abutting spans.

157. If neither of the girders under a track rests directly over a tower post, bracing shall be provided to carry the longitudinal force into the tower bracing without producing lateral bending stress in the cross-girders or posts.

158. **Sole and Masonry Plates.** Sole and masonry plates shall not be less than ¾ in. thick.

159. **Anchorage for Towers.** Anchor bolts for viaduct towers and similar structures shall be designed to engage a mass of masonry the weight of which is at least one and one-half times the uplift.

160. Anchor bolts, washers and other anchorage or grillage materials shall be furnished by the Contractor in time for them to be built into the masonry.

These specifications were followed by detailed specifications for materials, including structural and rivet steel, cast steel and cast iron; workmanship; weighing and shipping; painting; inspection; full size tests and erection.

Discussion

O. E. Selby (Chairman): The secretary tells me there is a great demand for these specifications for steel bridges. It has become known, of course, that they are under revision, and naturally people will demand the revised specifications. For that reason we ought to have the specifications as revised adopted in form to promulgate. Furthermore, there is every probability that the Engineering section of the A. R. A. will, under the relations newly established, be calling upon this association through this committee for specifications for the use of the U. S. R. A. I move the adoption of the conclusion, which includes the specifications printed.

F. E. Schall (L. V.): I find the old specifications had 163 paragraphs, and that the new ones have 317 paragraphs. It is impossible to form a correct idea of the great number of changes that were made in the specifications bearing on the sections required or the design of the bridges. It seems to me there are some things which must be changed before we adopt them. I move as an amendment that the specifications be discussed on the floor as long as possible, and that the rest be handled by correspondence, and the whole matter laid over until the next annual meeting.

Mr. Selby: I might give briefly the features in which the specifications proposed differ from the old ones. In the first place, they have been greatly amplified, as pointed out by Mr. Schall, and the number of paragraphs has about doubled. The amplification consists largely in parts covering workmanship and details of design. Those are not adequately covered in the old specifications. Specifications for erection have been added, so that the separate specifications for fabrication and erection which the association adopted at different times have been combined into one complete specification. In the matter of loads, there has been no change in the form of the loading, but we have specified E-60 loading as the minimum. In the column formula there is a change. We have introduced a parabolic column formula which is not self-limiting, and which has many advantages over the straight line formula in use in the old specifications. The impact formula is the one adopted by the convention a year ago. The clearance diagram is the general clearance diagram adopted by the convention two years ago. Those are the principal features that I think of which have been radically changed. Aside from that, however, a great many details have been amplified and some have been changed.

A. C. Irwin (Port. Cem. Assoc.): The specifications for steel railway bridges of the American Railway Engineering Association have had a wider and more universal use than any other specialized work produced by the association. However, the fact that we have never had a bridge failure is not proof that our designs have been economical and of the best. Very few railway bridges erected 25 or 30 years ago are now in service where they were originally constructed. Wheel loads in that time have so increased on main lines that the safe carrying capacity of parts of the structures was surpassed long before the physical condition of the bridges required their relegation to the scrap heap. This situation has brought about a very thorough investigation of the strength of what we choose to call old bridges. It was desired to retain the bridges in service at their original locations as long as practicable and we therefore began to apply to them *maximum safe unit stresses* and the heavy loading which it was desired to run over the line. And indeed for what ultimate purpose was the bridge design in the first place? We say to carry safely the heaviest loads that would be allowed to pass over it. Truly, but what was this load, and the answer is Cooper's E-40, 50 or 60, as the case may be. And what was the unit stress which was used in proportioning the various parts? The reply will range anywhere from 12,000 to 18,000 lb. per sq. in. with an "explanation" to the effect that this low unit stress was used to allow for a very considerable future increase in the live load. Then, after all, the bridge wasn't designed in the first place to fulfill the ultimate purpose of carrying safely the heaviest loads that were expected to pass over it.

The practical result of this logical or psychological error is almost humiliating to the engineering profession. You have had to move, scrap or sell many bridges whose chords were amply strong to carry the augmented loads, simply because of weakness in some web members or the absence of counters or because the floor beams or stringers or connections were not equally strong with the chords. In other words, you evolved an unbalanced design.

Now there is a cure for this, but the specifications presented here for your adoption do not give it. That cure is to design the bridge in the first place for the fulfillment of its ultimate purpose, namely, to carry maximum load, that is, use the maximum loading and the maximum unit stress in proportioning the various parts of the bridge—not two-thirds of the expected load or two-thirds of the maximum unit stress, but all of them.

Mr. Selby: The committee gave careful consideration to the points raised by Mr. Irwin in meetings at which Mr. Irwin was not present. It is recognized that the low unit stress design does not give a balanced uniform margin for increase in live loads. Both the technical and psychological aspects of that feature and the feature of design for an enormous increase over the existing live loads were carefully considered, and Prof. Turneaure is better prepared to tell why the specifications were presented in this form.

E. A. Frink (S. A. L.): There are a number of things in the specification that do not seem to be right, the principal one being the loading. The committee has proposed as a nimimum live loading Cooper's E-60 loading. If we use an E-60 loading for the engines that are in use to-day, we get too much metal in the super-structure, and too little metal in proportion in the floor system for structures of fairly long span; the Cooper loading is so entirely different from the engines in use to-day that it is no longer a fair measure by which to design the strength of our bridges. It seems to me that the time has come when this association should attempt at least to devise a standard load. Perhaps that is more of a problem than it might seem, but still I think we ought to attempt it.

As to prescribing a minimum of Cooper's E-60 for bridges when this specification goes into our Manual, it almost has the effect of a law. Any company which departs from this specification materially in designing its bridges might find the after-effects decidedly adverse. Therefore, we should be very cautious what loading we specify for our bridges.

J. R. Ambrose (Toronto Ter. Ry.): It is only fair to the members that they have sufficient time to express their views before you ask them to vote. I think it would be very interesting if you should ask Mr. Motley to let us know if there is any great difference between this specification which you are proposing now and the one which was proposed in the Engineering Institute of Canada.

P. B. Motley (C. P. R.) The Canadian Society's attempts at a specification are considerably different from this in various ways, in general principles. It is different in its order; it has completely revised its previous specifications in order of proceeding. For instance, loadings are mentioned first after general clauses, and then each process of design is allowed to rule in using the order of the various clauses. This specification does not apparently do that completely. In detail, it differs in many points, and I do not think it necessary to take up the time of this meeting in going into too many of those. As far as principles are concerned, I must say that I am in full accord, or mostly in full accord, with Mr. Irwin. We are not yet down to brass tacks in the method of applying our design. The Cooper's system of loading scarcely answers the condition of all locomotives to-day, but if we change to something like a Mallet, for instance, in 10 years we will have something different. It seems to me—this is my personal opinion only—that we will have to lean towards the European system of using a wisely arrived at uniform load. It seems to me that that is the tendency of our various thoughts and discussions. Probably the committee will discuss that in the next year's work.

Prof. A. N. Talbot (U. of Ill.): Mr. Chairman, it seems that all members of the Association and engineers generally will agree that it would be very undesirable to adopt specifications which have been in the hands of the members only two or three days. I feel the motion made by Mr. Schall is, therefore, one that should be adopted, the first part of it at least. As I understand, he put in at the end something considering these as tentative specifications during the year. It hardly seems that we should take these as tentative specifications, for they have no standing in the association for that term.

Mr. Schall: Mr. Chairman, with your permission, I will withdraw that second part of the motion that Prof. Talbot refers to, with the consent of my second.

Prof. F. E. Turneaure (U. of Wis.): Mr. Irwin's suggestion goes to the point of designing structures, having in mind more exactly the ultimate safe stress to which bridges may be subjected, and in proportioning the structure so that it will be what is called a balanced design when loaded to its maximum safe load.

In the rules for the examination of old structures adopted by the association some years ago an ultimate safe stress of 26,000 lb. was suggested as the stress up to which a structure might be loaded if the details were in satisfactory condition, and if the bridge showed no signs of over-stress. In accordance with that idea of ultimate safe stress, the committee discussed this particular method of arriving at a design, assuming that 24,000 lb. might be considered a safe stress with details all satisfactory and the load a perfectly static load. Should such a method be adopted, it would amount to this, that for a dead load we would design for that stress of 24,000 lb. per sq. in., or possibly 22,000 lb. per sq. in., and that for the live load we would take, not the load as indicated in the specification that is now passing over the structure, or that is anticipated in the near future, but the load that we would estimate might pass over the structure 30 or 40 years hence, and use 24,000 lb. for that live load, increased by the proper amount for impact, and in that way get a structure which would carry that load 30 years hence, say with a stress of 24,000 lb. per sq. in.

Is 24,000 lb. per sq. in. a satisfactory stress to put before the association, before engineers generally and before the public as a safe stress for all kinds of structures subjected to static load only? At the present time 16,000 lb. per sq. in. is the common ordinary stress used in a great variety of structures. I think any experienced engineer would be perfectly willing to design a structure, if he had supervision of all the details for a load perfectly static, which never would increase, using an ultimate safe stress of 22,000 to 24,000 lb. per sq. in., and be able to sleep nights.

The committee did not feel that it was desirable to set forth 24,000 lb. per sq. in. as a safe stress for dead loads. That line of argument was carried on in the committee with reference not only to 24,000 lb. per sq. in., but with reference to 18,000 to 20,000 lb. per sq. in. as a basic dead load stress. The result that the committee arrived at after a good deal of discussion is indicated in the specifications. The difficulty, of course, arising from that method of design is well known, and many structures have been analyzed for increased live loads which have shown that the web members are the weakest elements in the structure when it comes to permitting the passage of an extremely heavy live load. That difficulty is met fairly well, in the minds of the committee, by Article 45, which provides just this: If we take 24,000 lb. as the ultimate safe stress for an overloaded structure, this rule will provide precisely 75 per cent overload capacity for the live load part of the load. That is practically the same percentage of overload capacity that is provided in the chord members of a 200-ft. span.

B. R. Leffler (N. Y. C.): Mr. Chairman, I wish to call the attention of the members of the association to the first line in this specification, "These specifications are limited to spans of less than 300 ft." One of the reasons for that was, that it was recognized that when long

spans are to be designed some method of using higher unit stresses must be used, and such long spans also require special engineering features. Another paragraph that has not been mentioned as tending to make a balanced structure is paragraph 27. It was recognized that in heavy ballasted floor bridges this load was of such great importance that some adjustment should be made to take care of it.

Mr. Irwin: I agree entirely with Mr. Leffler that these are steps in advance. They are attempts to cure this proposition of an unbalanced design that have met every man who has had to figure out whether or not such and such a locomotive could pass over such and such portions of the line, and it is an attempt to relieve him of the embarrassment that he meets when he finds that because of certain small weaknesses in this bridge the large expense incurred in building it in the first place must be largely thrown away, because the man who designed the bridge did not have in mind the fulfillment of the things that that bridge was supposed to do with the biggest load that ever came upon it. These are steps in the right direction, but if you consider the fact that your bridges will have spans from very small ones up to 300 ft. according to this specification, you will have a perfectly enormous problem. There is just one way to do it, that is to consider and proceed from the fundamental proposition of designing the bridge for the maximum load and maximum unit stress.

(The original motion as amended by Mr. Schall was put to a vote and carried.)

The Chairman: The report is received as a progress report.

Mr. Selby: I talked with a member of the Bureau of Standards yesterday and asked him what the prospects were for a continuation of the column tests in the Bureau of Standards now that the war conditions have passed. Mr. Brooks told me he was in touch with that part of the work of the bureau and he felt sure that some progress could be made this year on those tests. The work of making the tests is in the hands of the subcommittee, headed by W. H. Moore, and we are only waiting for an opportunity to conclude the tests.

(Mr. Selby then read the matter on design of turntables and recommended that the subject be dropped.)

Mr. Frink: Why should the subject be dropped?

Mr. Selby: For the reason that the principal materials for turntable rollers and disc bearings are steel for the rollers and phosphor bronze for the disc. The phosphor bronze specifications have been carefully considered and adopted by the association and the matter of steel for the rollers is included in the movable bridge specifications which have been printed in the proceedings and will be offered next year for adoption.

(Mr. Selby read the matter on ballast floor bridges.)

Mr. Selby: The details under this heading are expected to be presented to the convention in the report of 1920.

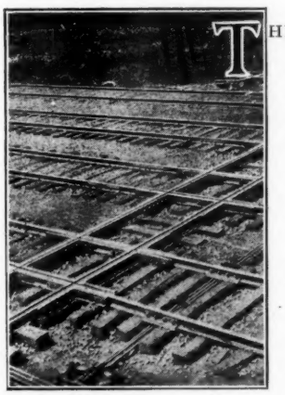
(Mr. Selby read the matter on track scales.)

Mr. Selby: The committee will ask that this subject be continued, for the reason that the track scale question is a very live one and has been referred to this association by the Railroad Administration, and this committee would like to keep in touch with the structural features, at least, of the track scale.

I move the adoption of Sec. 2 of the recommendations.

(The motion was carried and the committee dismissed with thanks.)

Report on Uniform General Contract Forms



THE COMMITTEE CONSIDERED the form of agreement for railway crossings at several meetings. The Form of Agreement for Railway Grade Crossings herewith submitted is the result of action taken at these various meetings. No attempt has been made to specify a basis upon which the expense for construction, maintenance and operation shall be divided. In this respect the submitted Form of Agreement conforms with the Form of Agreement for Interlocking Plant, submitted by this committee and approved by the Association at the last annual meeting. Similarly while articles covering liability and arbitration are incorporated in the submitted form in order to complete the same, it is recognized that these two articles will doubtless be modified in many cases to meet local conditions and the views of various legal departments of railroads.

It will be noted that seniority as between companies has been given no specific recognition in the submitted form. The committee has assumed that seniority will be given due weight in concluding the bargain which will be made in each case. The committee further assumes that in general the senior company will prefer to retain the actual work of constructing, maintaining and operating the grade crossing in its own hands.

Committee: E. H. Lee (C. & W. I.), chairman; C. A. Wilson (Cons. Engr.), vice-chairman; C. Frank Allen, O. P. Chamberlain, A. O. Cunningham (Wabash), Thos. Earle (Beth. Steel Br. Corp.), W. D. Faucette (S. A. L.), G. E. Gifford, J. C. Irwin (B. & A.), R. G. Kenly (M. & St. L.), A. S. Kent (C. I. & L.), H. A. Palmer (G. T.), C. J. Parker (N. Y. C.).

Appendix A. Agreement for Grade Crossing

THIS AGREEMENT, made this.....day of..... in the year....., by and between..... party of the first part, hereinafter called..... and....., party of the second part, hereinafter called.....

(Note.—During Federal control terminology should conform to requirements of Federal Administration.)

HISTORICAL. WHEREAS, ...

.....

(Note.—Include brief description of conditions, including the location of existing or proposed grade crossing, an enumeration of all existing agreements, if any, the name of the companies between which agreements are made, their dates, their purpose, et cetera.)

WHEREAS, ... desires the right to construct, maintain, use and operate a grade crossing across the tracks and right-of-way of..... to permit the passage of its trains over and across the right-of-way and tracks of ..... and ..... is willing to grant said right; the location of said crossing and its proposed arrangement being shown upon a blueprint marked "Exhibit A," dated ....., identified by the signature of the ..... of ..... and of .... of ..... hereto attached and hereby made a part of this agreement; and

WHEREAS, The parties hereto have agreed upon the

terms and conditions upon which said crossing as shown upon said "Exhibit A" shall be constructed, maintained and operated.

NOW, THEREFORE, In consideration of the premises and in further consideration of the mutual covenants and agreements hereinafter stipulated to be kept and performed, it is mutually agreed between the parties hereto, for the purpose of defining the terms and conditions upon which said crossing shall be constructed, maintained, renewed and operated, as follows:

1. DEFINITION. The term crossing as herein contained shall include rail, crossing frogs, track fastenings, crossing timbers, and other track appliances, included between the outer joints of one or more crossings installed or hereafter installed; together with ballast, drainage, side ditches, subdrainage, and other substructure appliances, devices or supports on the right-of-way ..... Company in so far as affected by said crossing; all necessary buildings, including flagmen's houses, shanties or towers; gates, semaphores and other safety devices or appliances; all as may be required to keep said crossing in safe and suitable condition for the operation of trains, as required by ..... Company or by lawfully constituted public authority.

2. GRANT. ..... hereby grants to ..... subject to the conditions and stipulations of this agreement, the right to construct, maintain, renew and operate at grade....., track ..... of the ..... Railroad, over and across the right-of-way and tracks of ..... at the point of crossing, as shown on "Exhibit A."

3. CONSTRUCTION. The ..... Company agrees to construct a grade crossing as shown upon said "Exhibit A" and according to detail plans and specifications, which have been approved by the ..... Engineer of the ..... and identified by ..... signature. The said ..... Company agrees to begin the construction of said crossing within ..... days after the execution of this agreement and to carry the same forward continuously to prompt completion.

4. APPORTIONMENT OF COST. The cost of constructing, maintaining, renewing and operating said crossing shall be borne by the respective parties hereto as follows:

.....

In the cost of maintaining and renewing said crossing shall be included the expense for taxes, assessments, and insurance; any losses by fire, floods and other damage caused by the elements; also any change made necessary by an act or ordinance of a lawfully constituted public authority, except as herein otherwise provided.

5. EXTENSIONS AND CHANGES. (a) The ..... Company reserves the right to construct, maintain, renew and operate upon its right-of-way from time to time such other additional track or tracks as it may deem necessary or desirable crossing the track or tracks of the ..... Company, the right to construct which is herein granted, and all the provisions and stipulations herein contained shall apply to such other additional track or tracks.

(b) The ..... Company reserves the right to change the grade of its track or tracks as shown on said "Exhibit A" not to exceed ..... feet, and the grade of the crossing shall be changed to conform thereto. The expense of so changing shall be borne as follows:

.....

(c) Either company shall have the right at its own expense to make minor changes in alinement at said crossing, provided that this shall not materially interfere with the tracks of the other party, but nothing herein contained shall be interpreted to cover major changes in grade or alinement, such as separation of grade or elevation of tracks required or brought about by laws or ordinances of properly constituted public authorities.

(d) Improvements or devices which may be necessary in order to conform to the standard practice of the ..... Company shall be provided as required by that Company, and the expense shall be borne in accordance with the provisions of Section No. 4 hereof.

(e) The privileges hereinbefore granted are granted upon the further express condition that whenever anything may be done or may be required to be done by the Chief Engineer of ..... Company, or under and in pursuance of any of the laws of the State of ....., or of any lawful action of proper public authorities in respect to the said crossing, including the installation of gates, signals or interlocking, the ..... Company shall make all changes at said crossing and in present or future tracks of both companies and their appliances, necessary to comply with or carry out the requirements of the Chief Engineer of the ..... Company or of law, or action of such authorities, and the cost thereof shall be apportioned in accordance with Article 4 hereof.

(f) It is further understood and agreed that the ..... Company will pay the cost of any connecting or transfer track or tracks that may, at any time, be required at or near the point of the crossing aforesaid, whether such track or tracks be ordered by competent authority, or put in by agreement between the parties hereto. If the junction switches of the said connecting track or tracks in the main track or tracks of either of the parties hereto shall be or come to be within the limits of an existing interlocking plant, said junction switches shall be taken into the protection of said interlocking plant and the cost shall be borne as follows:

.....

6. MAINTENANCE AND RENEWAL. The crossing shall be maintained by the ..... Company. In case .....Company shall remove its tracks or any of them at said crossing, the track or tracks of the ..... Company shall be restored by the ..... Company to their original condition, to the satisfaction of the Chief Engineer of the ..... Company, and at the sole cost and expense of the ..... Company.

7. CONTROL. The maintenance, renewal, operation and protection of said crossing shall be under the sole charge and control of the ..... Company, and it shall employ competent persons to maintain, renew and protect the same, and such parties from time to time so employed shall be removed for good and sufficient reason upon request in writing of a general managing officer of the ..... Company.

Each of the parties hereto, through its authorized employes and representatives, shall have the right at all times to inspect said crossing, as well as the accounts covering the construction, maintenance, renewal and operation of the same; and in the event that the ..... Company shall notify the ..... Company in writing of renewals and repairs that may be necessary for the safe and proper operation of said crossing, and if the ..... Company neglects for a period of thirty days to make said necessary renewals and repairs, then the ..... Company shall have the right to make such renewals and repairs, and the ..... Company shall, upon presentation of proper bills, and within the time provided in Section 11 hereof, pay its proportion of the amount so expended.

8. PROTECTION. During construction and thereafter, flagmen or signalmen shall be furnished for the proper protection of said crossing, and such persons from time to time so employed shall be removed for good and sufficient reasons, upon request in writing of a general managing officer of the ..... Company. The expense

for their wages, together with the cost of materials and supplies required in connection with their work, shall be apportioned as herein in Article 4 provided. Until interlocking protection shall have been provided, all trains shall approach said crossing under full control, and shall come to a full stop within ..... feet from said crossing, and shall not proceed until the receipt of a proper signal so to do.

9. PRECEDENCE. In the use of said crossing, passenger, mail and express trains shall have precedence over freight or work trains and light engines, and freight or work trains shall have precedence over light engines. The trains and engines of the ..... Company shall have precedence over the trains and engines of like class of the ..... Company.

10. OWNERSHIP. Each of the respective parties hereto shall participate in the ownership of the crossing in the proportion which the payments made by it for construction of same bear to the total cost of construction.

11. PAYMENT OF BILLS. The payment of all bills under this agreement shall be made not later than the twenty-fifth day of the month following the month in which said bills are rendered. The bills for expense of construction shall be made as a final bill, unless otherwise mutually agreed and understood.

Bills covering maintenance, renewals and operation, taxes and assessments shall show total expenditures, and proportions chargeable to each of the respective parties hereto, and shall be rendered monthly; those covering insurance, taxes and assessments annually.

Should any dispute arise as to the correctness of any of the items included in bills rendered, under this agreement, the party against which any such bill is rendered, shall pay as herein provided, an amount equal to the sum of all items in said bill, the correctness of which is unquestioned. The remainder, covering disputed items, shall be paid promptly as herein provided, upon an adjustment of the dispute.

12. ADDED PERCENTAGES. In making bills for the cost and expense of constructing, renewing, maintaining, operating and protecting said crossing, all labor and material shall be charged for at actual cost, plus ..... per cent added to material, and ..... per cent to labor to cover freight charges or accruals, handling, superintendence, use of tools and accounting, except that work done by contract shall have no percentages added.

Such of said bills as are based upon payroll cost of labor and stock prices of material shall include a fair arbitrary charge to cover supervision, inspection, handling, transportation, accounting and similar undistributed items of expense. Such fair arbitrary charge shall be agreed to by the parties, or determined by arbitration as hereinafter provided.

The provision as to actual cost herein contained shall not be considered or held as a warrant for charging excessive prices or freight rates on material, for hauling the same unreasonable distances, nor for the payment of unreasonable arbitrary charges of any kind.

13. LIABILITY. Each party hereto assumes for itself the responsibility and risk of using and operating its own trains and engines over the space covered by the said crossing, and also responsibility for the negligent acts and omissions or the alleged negligent acts or omissions of its own officers, agents, servants and employes engaged in connection therewith; and in performance of any of its separate duties under this contract; and will pay to the other party and to third persons all damages which may arise and for which it may be liable arising from such negligence and in such operation.

The party having special charge of the management and operation of said crossing shall not be liable to the other party for the negligent acts or the omissions, or the alleged negligent acts or omissions of any person employed in the operation, maintenance or repair of said crossing, but all persons so employed shall, as respects any injury caused by such negligence, be regarded and treated as the agents or servants of each party hereto, and each of said parties hereby assumes the responsibility for all damages resulting from the negligence of such agents or servants in the operation of its own engines, cars and trains, and those of its tenants, lessees and licensees, at the said crossing, and shall indemnify and save each of the other parties harmless therefrom. Any expense caused or growing out of the injury of any workman or employe engaged upon the construction of said crossing shall be held and considered to be a construction expense, and shall be divided as herein in Section 4 provided.

14. ARBITRATION. In case of any differences or dispute arising under this agreement or concerning the subject matter thereof, the parties hereto agree to submit such difference or dispute to three arbitrators, one of whom shall be appointed by the ..... Company, and another by the ..... Company, and each party shall give to the other party written notice of appointment of its arbitrator, together with his name and address. The two arbitrators so chosen shall select a third arbitrator. If either party shall fail to choose an arbitrator as herein provided, the arbitrator selected by the other party hereto, at the expiration of ..... days after the date of its said written notice, shall select a second arbitrator, and the two arbitrators so chosen shall select a third arbitrator. If within ..... days after the appointment of a second arbitrator, as herein provided, the two so chosen shall have failed to select a third arbitrator, either party hereto may apply to any judge of the District Court of the United States for the District which shall then include ..... or who shall thereupon appoint the third arbitrator. The three arbitrators so chosen in any manner as herein provided, or a majority of them, shall hear and decide said difference or dispute, and their decision, or that of a majority of them, shall be final and binding on the parties hereto.

The expense of an arbitration under the terms hereof shall be borne by the parties hereto in the proportions fixed by the arbitrators.

15. CANCELLATION OF CONFLICTING AGREEMENTS. It is mutually understood and agreed that any and all agreements relative to said crossing, existing between the parties hereto or their predecessors, so far as they conflict, or are inconsistent with the terms and provisions of this agreement, are hereby annulled, but in all other respects they shall continue in full force and effect.

16. DURATION AND SUCCESSION. This agreement shall remain in full force and effect as long as the tracks of the respective parties cross at grade at the location shown upon "Exhibit A."

The provisions of this agreement shall be binding upon and inure to the benefit of the parties hereto, their successors, lessees and assigns.

IN WITNESS WHEREOF, the parties have caused these presents to be executed in duplicate by their respective officers as of the day and year first above written.

ATTEST: .....Company

..... By.....,

Secretary. .....(Title)

ATTEST:

....Company

Secretary. By.....,

.....(Title)

Discussion

E. H. Lee (Chairman): The agreement which the committee offers to the association is shown in Appendix A, and we wish to add two additional sections to that agreement. Your committee feels that under all the conditions, taking the country over, a really uniform contract form is difficult to provide, one which will adequately meet all the various conditions in the various sections of the country. Some of the provisions must be suggested and with that in mind, these two additional paragraphs which we wish to offer, are to be incorporated in the agreement as shown in Appendix A, as sections 9 and 10, covering two matters which should be covered in certain cases. It might be well to run through the "Agreement for grade crossings," which is submitted.

(Mr. Lee then read Appendix A, down to and including "Protection.")

Mr. Lee: At this point we wish to offer to the association two additional paragraphs, one to cover the cattle guards and fence, and another to cover the question of electrification of lines as follows:

Section 9—The ..... Company reserves the right so long as it maintans fence up to the point of intersection of the ..... company's track with the respective boundary lines of the ..... company's premises, to require the ..... company to build and maintain in good order, proper cattle guards at the point of intersection aforesaid, for the purpose of preventing trespass upon said company's premises from the track or grounds of said ..... company.

Section 10—If the ..... company shall (during the life of this contract) electrify its railroad at the said crossing, upon ..... days written notice to the ..... company, the said ..... company agrees to furnish, maintain and install such electric appliances, fixtures and appurtenances at said point of crossing as many be necessary for the safe and convenient operation of said crossing, and to the satisfaction of the company's engineer.

If there is no objection, that will be incorporated. With those two additions, and with the further stipulation that Articles 9 to 16, inclusive, be set further back so that they shall be 11 to 18, inclusive, your committee wishes to offer the form submitted in Appendix A. I move that this form be adopted by this association for incorporation in the Manual.

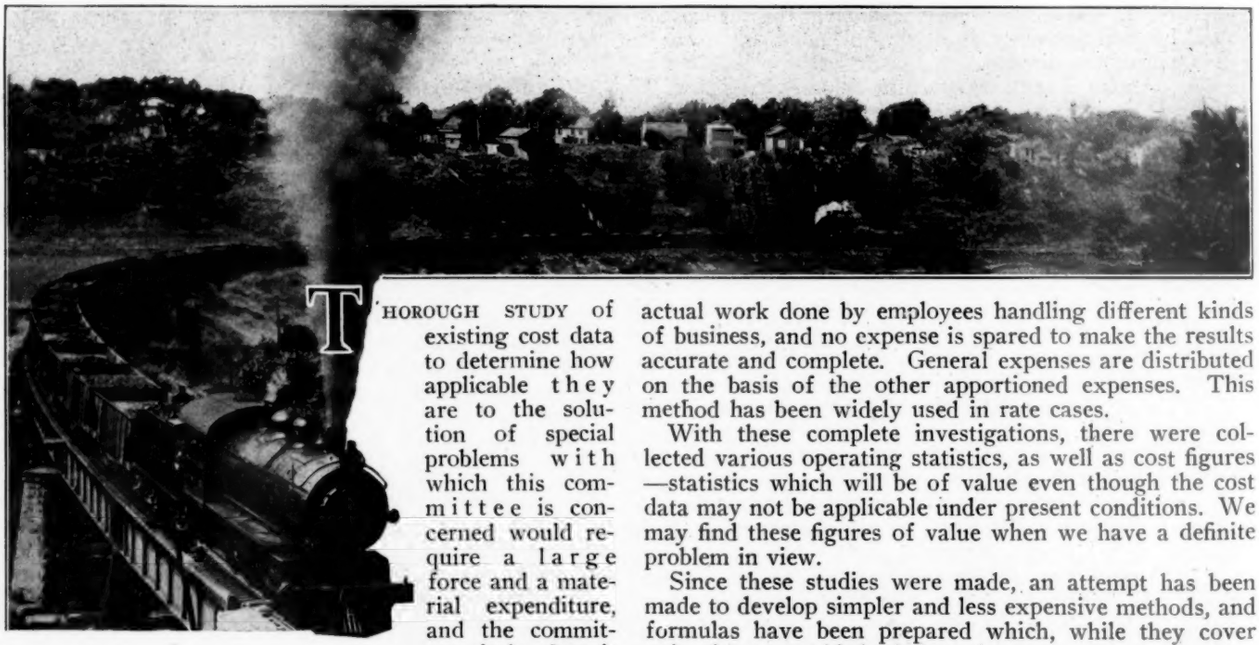
G. W. Kittridge (N. Y. C.): I have been making contracts a good many years. The day before I left home to come here I had submitted a contract which read the same as this one does, in one particular, and it came back. They told me that if I wanted to make a blue print and have it identified by signature of the blue print hereto attached, it should not appear in the whereas, but after "It is mutually agreed." There may be some legal reason why that should come after "Therefore it is mutually agreed" than to put it in one of the whereases.

Mr. Lee: The committee would like to take this under consideration.

The Chairman: The motion before the house is the adoption of this tentative form of report, and insertion in the Manual.

(The motion was carried and the committee was dismissed with thanks.)

Report on Economics of Railway Operation



THOROUGH STUDY of existing cost data to determine how applicable they are to the solution of special problems with which this committee is concerned would require a large force and a material expenditure, and the committee feels that it should study the methods of analyzing costs rather than the costs themselves.

The Minnesota Rate Case made an epoch in cost accounting by insisting on more accurate information as a basis for rates. The "Arkansas Formula" was developed as a result of the decision, and was first used to find the cost of handling intrastate freight business. The "Formula" is a detailed method of assigning operating costs to the different services performed. Records are kept of actual work done by employees handling different kinds of business, and no expense is spared to make the results accurate and complete. General expenses are distributed on the basis of the other apportioned expenses. This method has been widely used in rate cases.

With these complete investigations, there were collected various operating statistics, as well as cost figures —statistics which will be of value even though the cost data may not be applicable under present conditions. We may find these figures of value when we have a definite problem in view.

Since these studies were made, an attempt has been made to develop simpler and less expensive methods, and formulas have been prepared which, while they cover only about one-third of the primary accounts, take care of about 85 per cent of the expense. The items which are omitted are mainly the unimportant ones which cannot be easily classified and which can fairly be divided on the basis of other costs.

New operating statistics are being prepared under the direction of the U. S. Railroad Administration. It seems probable that the methods adopted will lead to valuable results, and it is to be hoped that the work may be continued and where found to be an improvement over old

methods, it should be adopted by the Interstate Commerce Commission. It is not thought necessary here to discuss these new statistics. Reference is made to the article by William J. Cunningham, in the *Railway Age* of January 3, 1919, page 43.

Economic Length of Operating Districts

OPERATING DISTRICT—The section of a railroad extending between terminals where yard and enginehouse facilities are provided which is covered by slow freight trains in single runs, trips, turns or day's work.

The economic length or lengths of operating districts of a given railroad are those with which the sum of interest on first cost, depreciation and maintenance of road and equipment, and cost of operation, may be the minimum.

On account of varying speeds the economic length of engine districts for (a) through passenger trains, (b) local passenger trains, (c) preference or quick dispatch freight trains, (d) local and pick-up freight trains, and (e) slow freight trains handling full engine rating, are not always the same, and for this reason it is essential to draw a distinction between engine districts and operating districts. To a large extent the present practice is for passenger engines and engine and train crews to cover more than one operating district in a turn or day's work, either by longer straight-away runs or by doubling one or more operating districts or portions thereof. To a considerably less extent the same is true of fast freight trains, and local and pick-up freight trains frequently have runs shorter than the operating districts. Therefore, in determining the economic length of operating districts it will be sufficient to consider the term "operating district" as applying only to slow freight trains.

The factors affecting the length of operating districts of existing lines are:

(1) Location of existing yard and enginehouse facilities.

(2) Topographical conditions affecting the construction of new yards and enginehouse facilities.

(3) Character of grade line.

(4) Capacity of railroad for handling business to be moved.

(5) Density of (a) passenger traffic; (b) fast freight traffic; (c) slow freight traffic.

(6) Location of labor supply and of housing facilities of employees.

(7) Location of connections with important feeders where there is heavy transfer of traffic from one to another, commonly termed "gateways."

All of these except No. 1 apply equally to new lines to be constructed except that the quantity of traffic frequently has to be estimated rather than determined from actual records.

The change in length of operating districts on existing lines has in the past been brought about by existing yard and terminal facilities being outgrown and on account of their inadequacy causing serious congestions of traffic rather than by any other cause. There are very few cases, if any, of new terminals on existing lines having been established solely for the purpose of changing the length of operating districts to promote economy. Usually a terminal becomes congested and topographical conditions are such that it is not practicable to increase its capacity. After a study of the situation it is found advisable to build a terminal in a new location, and this changes the lengths of the operating districts.

The disposal of existing terminal properties, the cost of new terminals and the breaking-up of established places of residence of employees are questions of such importance that it is rarely the case that any considerable change in the length of operating districts on an existing road has been justified alone by the resulting economies, and it is not possible to establish any rules or formulas which can be followed with any degree of certainty.

Aside from the questions of providing facilities for increased business, the principal items of operating and maintenance expense affected by the length of operating districts are: (1) Wages of train and engine crews. (2) Fuel and supplies for engines. (3) Cost of dispatching engines. (4) Cost of switching at additional terminals. (5) Train dispatching and telegraph expenses. (6) Maintenance of yards and engine terminals. (7) Maintenance of locomotives (locomotives required, both road and yard, increase as the number of operating districts increase). (8) Inspection and maintenance of cars, as affected by switching at additional terminals.

Take as a simple example a railroad of 500 miles operated under

Scheme A—Four operating districts of 125 miles each.

Scheme B—Five operating districts of 100 miles each.

(1) Under favorable conditions many freight trains will cover the 100-mile districts in from six to eight hours and a part of the wages of train and engine crews will be for "constructive" hours, and hence unproductive. With 125-mile districts this will not be so, or there will be less of it, and the wages of train and engine crews will be reduced accordingly, excepting as to such overtime as might be made on a longer district.

(2) Then if freight trains move at an average speed of 12½ miles per hour between terminals it will take a locomotive

$$\text{Scheme A} — \frac{500}{12.5} + 6 \times 4 = 64 \text{ hours}$$

$$\text{Scheme B} — \frac{500}{12.5} + 6 \times 5 = 70 \text{ hours}$$

to move a train over the 500 miles, one way. It will therefore require

$$\frac{70 - 64}{64} = .09375 = 10 \text{ per cent (approximately)}$$

more road locomotives with Scheme B. Switching at the additional terminal will require at least two switch engines, so that if 60 road engines are required with scheme A, then $60 + .10 \times 2 = 8$ additional engines will be required with scheme B and the cost of fuel and supplies for these engines will be additional expense with this scheme.

(3) With scheme B there will be 6 terminals, 4 intermediate, while with scheme A there will be 5 terminals, 3 intermediate. The number of engine dispatchments under scheme B will be approximately one-fifth more than under scheme A and an additional supervisory and working force will be required, embracing ashpit, engine house, coal dock, power house and miscellaneous labor.

(4) Incident to the additional intermediate terminal under scheme B there will be a certain amount of switching and a force of yardmasters, yard-clerks, switchmen, etc., required, adding to the expense of operation under this scheme.

(5) On account of there being an additional operating district another set of train dispatchers will be required under scheme B and the additional terminal will add at least one telegraph office.

(6) The yard tracks, buildings and appurtenances of the additional terminal under scheme B will have to be maintained and will add to this expense approximately one-fifth.

(7) There will be, as developed above, 6 road and 2 yard locomotives more required under scheme B. These will have to be maintained at approximately the average cost of maintenance of all locomotives under scheme A.

(8) A force of car inspectors will be required at the additional terminal and there will be a certain amount of damage to equipment in switching there, requiring repairs to the cars. This will add to the cost of repairs to cars under scheme B.

This indicates briefly the result on the cost of operation of the establishment of additional terminals, so long as the lengths of the operating districts are held within practicable limits. However, the exercise of care and good judgment is necessary in making the decision between very long or moderately long districts. If the districts are very long, the average time of the crews on the road will be too great and there will be great likelihood of having to relieve them to avoid violations of the Hours of Service law. Moreover, the factors affecting the length of operating districts Nos. 2 to 7, inclusive, have such an important bearing on the location of terminals and the economic length of operating districts that it is plainly evident that each case presents a problem in itself, which can be solved correctly only after a careful study of its own peculiar conditions. There are, however, certain principles which should be kept clearly in mind in determining the economic length of operating districts. These may be stated as follows:

(a) The number of terminals at which trains are switched and engines dispatched has a direct bearing on the cost of operation and should be a practicable minimum.

(b) It is advantageous to so locate terminals that locomotives will haul full tonnage rating over the entire operating district.

(c) It is advantageous to locate terminals at the intersections of natural railroad routes which will develop into important gateways.

Conclusions

The committee recommends the acceptance of this report as information, it being considered unnecessary to insert any portion of the report in the Manual at this time.

The committee recommends the assignment for the coming year of four subjects, as follows:

(1) Report on methods for increasing the capacity of a railroad, collaborating with the committee on Signals and Interlocking.

(2) Report on method of analyzing costs, for the solution of special problems with which this committee is concerned.

(3) Effect of speed of trains upon cost of operation. (This year's subject covered effect upon track maintenance only.)

(4) Report upon the allocation of maintenance of way expense to passenger and freight service.

Committee: F. W. Green chairman; V. K. Hendricks (St. L.-S. F.), vice-chairman; H. H. Brewer (G. T. P.), G. D. Brooke (B. & O.), Ralph Budd (G. N.), M. Coburn (Pa. Lines), C. E. Denney (N. Y. C. & St. L.), J. M. Egan (I. C.), L. C. Fritch (C. R. I. & P.), U. E. Gillen (G. T.), M. V. Hynes (C. I. & W.), C. M. Himmelberger (C. R. R. of N. J.), W. J. Jenks (N. & W.), P. M. LaBach, Frank Lee (C. P. R.), J. de N. Macomb (A. T. & S. F.), Jos. Mullen, H. A. Osgood, R. J. Parker (A. T. & S. F.), J. H. Prior (Cons. Eng.), W. G. Raymond (Univ. of Ia.), H. E. Riggs (Univ. of Mich.), S. S. Roberts (U. S. R. R. A.), L. S. Rose (C. C. C. & St. L.), E. F. Robinson (B. R. & P.), Mott Sawyer (C. M. & St. P.), Edward C. Schmidt, J. E. Teal (B. & O.), G. S. Ward (S. P.), C. C. Williams (Univ. of Kan.).

Discussion

V. K. Hendricks (Vice-Chairman): The report of the committee is merely a report of progress on subjects (1) methods of increasing the capacity of a railroad, (3) effect of speed of trains upon cost of track maintenance, and (5) allocation of maintenance of way expenses to passenger and freight service. The investigation on the collection of data on operating costs indicates that a thorough study of existing cost data would be a very expensive proposition. It would require a paid force to make it, and while the committee recommended last year that such study should be made, it feels that the cost data would be of questionable value, on account of the changing in unit prices, and that it would be better to study the methods and analyzing costs, rather than to study costs themselves, and on this subject merely report progress.

On Subject No. 4, "Report on the economic length of operating districts," the question has been gone into at some length, but it seemed that this question was dependent on a full consideration of all the varying features entering into it, and the application of good judgment, and no definite recommendation is made.

J. L. Campbell (E. P. & S. W.): It is doubtless true that this is a subject in which the association should have the benefit of the co-operation and experience of distinctly operating men, and I suppose that they are properly represented on this committee. If they are not, the committee might be enlarged so that the strictly operating men who are members of the association could work on this subject. I believe that it is going to be recognized by this association that this is perhaps one of the very important, perhaps the most important, of committees.

Mr. Hendricks: In this connection the personnel of the committee does include a good many operating men, but unfortunately during the past year the conditions have been such that they could not devote time to this work, and I am sure that we all regret that they have not been able to do so to a greater extent.

Col. F. W. Green (Chairman): The speaker regrets that his military obligations were such that he has had no time to give consideration to these matters heretofore. It seems to him that just at the present time the work of this committee is going to be especially difficult, for several reasons; First, we are in a period of flux, as we all know, labor costs and material costs are reaching unheard of figures and it is almost impossible for anyone to estimate today with any degree of accuracy what these costs will be tomorrow, or a year from now, or three years from now.

The true significance of the term "economics of railway operation" is, of course, to secure that combination of facilities and the operating organization which will result in the least total expenditure of money. Both of these items will be variable and uncertain, and it seems to me for the next year or two, possibly, the work of this committee will have to be confined to the establishment of principles, rather than the development of any definite method for ascertaining costs.

Mr. Hendricks: I move that the report be received as information.

(The motion was carried, and the committee dismissed with thanks.)

Report on Economics of Railway Location

Sub-committees were appointed to consider each of the five subjects assigned to the committee for study, but four of the chairmen of the sub-committees asked to be relieved and only one advised that he would undertake the work. As a result, only one sub-committee did any work. This committee made a study of the effect of curvature on the cost of maintenance of way and equipment. A letter of inquiry was addressed to the officers of a few lines asking for information bearing upon this subject. Several replies were received, but the only information obtained was from the Pennsylvania Lines (published in the *Railway Age*, November 8, 1918, page 813). This data showed that the average increase in rail wear on curves as compared with tangent is about 100 per cent for a 6 deg. curve, 25 per cent for a 3 deg. curve, etc., or approximately as the square of the degree of curve. The importance of this information is evident when it is remembered that heretofore it has been customary to estimate curve expenses directly with the central angle or with the degree of curve when a given length is considered.

Committee: R. N. Begien (B. & O.), chairman; C. P. Howard (I. C. C.), vice-chairman; F. H. Alfred (P. M.), A. S. Baldwin (I. C.), Willard Beahan (N. Y. C.), E. J. Beugler, Ralph Budd (G. H.), W. J. Cunningham (U. S. R. R. A.), C. F. W. Felt (A., T. & S. F.), R. D. Garner (Soo N. E.), A. S. Going (G. T.), A. J. Himes (N. Y. C. & St. L.), H. C. Ives (Wov. Pdy. Inst.), W. A. James (C. P. R.), J. A. Lahmer (M. P.), Fred Lavis (Cons. Engr.), E. H. McHenry, G. A. Mountain (Can. Ry. Cons.), Edward C. Schmidt, A. K. Shurtleff (Asst. Secy.), C. H. Splitstone (Erie), M. F. Steinberger (B. & O.), A. F. Stewart (C. N.), L. L. Tallyn (D., L. & W.), Robt. Trimble (Pa. Lines), W. F. Tye (Cons. Engr.), W. L. Webb (Cons. Engr.), H. C. Williams (L. & N.), M. A. Zook (I. C. C.).

Discussion

C. P. Howard (Vice-chairman): Five subjects were assigned to this committee, but only one sub-committee submitted a report—Subject 3 (a) "Effect of curvature on cost of maintenance of way."

(Mr. Howard here read the report of the committee.)

I would like to call attention to the fact that though the text of this report is brief, the conclusion indicated by the data submitted is entirely new and altogether different from the theory heretofore accepted, that curve expenses, including rail wear generally, vary directly with the degrees of central angle, irrespective of the degree of curve. It has been known a long time that sharp curves were very objectionable, Wellington to the contrary notwithstanding; but this is the first time as far as known that any data has ever been submitted tending to show that excess rail wear on curves and perhaps some other curve expenses, vary with the square of the degree of curve.

This data and the conclusion that might be drawn from it would necessitate a radical change in the ordinary rules for the negative value of curvature, and it is hoped that discussion of the subject and especially the submission of additional data from the railroads will throw further light on the subject and enable us to reach a positive conclusion in the matter.

G. J. Ray (U. S. R. A.): I would like to ask whether in considering the data received any attention was paid to the question of elevation in the curves in making comparison. That has a very vital influence in considering the matter for this reason. In the case of all freight traffic you would have very low elevation. In the case of combined freight and passenger traffic, if you have a high elevation with freight trains, probably moving at a slow rate of speed, which is the worst possible condition, we know that the rail wear has a very damaging effect.

Mr. Howard: This does not give the elevation on curves. It covers two divisions of the Pennsylvania, and I suppose the elevation is such as is usual. We have only been able to get data from one railroad, though we have circularized various roads.

C. E. Lindsay (U. S. R. A.): I happen to know that these particular tracks are used for both freight and passenger, and are probably elevated for about forty miles per hour.

Mr. Howard: It is not so much the amount of wear as the fact that it increases as the square of the degree of curve.

W. H. Courtenay (L. & N.): I appreciate the very great value to all railroad men of getting as precise data as is possible pertaining to the wear of rails on different curves, but in the ordinary maintenance and operation of a railroad it is difficult to get data which is scientifically precise for the simple reason that rails are sometimes renewed on a given railroad in a less state of wear than they are on another railroad. Our experience on coal-carrying lines with 10-deg. curves is that the rail on the curves ought to be renewed at intervals of about four years. On 6-deg. curves we can count on a life of eight years, and for straight track about twelve or thirteen years. While those are very rough figures, I apprehend it will be very difficult to get figures which are so nearly correct as to be reasonably scientifically precise upon which this association could base any general conclusion.

E. B. Katte (N. Y. C.): In studying this question of rail wear I should think that co-operation with the motive power engineers might be helpful. We know that the flange wear on certain types of electrical locomotives is very much greater than on other types.

Mr. Courtenay: There is one other thing that I omitted. The wear on the curves was so great that we went to oiling the flanges, and at certain curves we actually oiled the gauge of the outer rail. That is a laborious undertaking, but it apparently reduced the wear. To what extent I cannot say.

Mr. Howard: I might say for Mr. Courtenay's information that this report from the Pennsylvania was originally made on just that subject, to find out whether or not it paid to oil rails, and this data and the study of the rail wear was gotten from that investigation. All that part about oiling the rail has been left out of this report. As to ascertaining the time a rail has lasted in a curve, the Interstate Commerce Commission is doing that now every day. They go over miles of railroad and look at the brand on the rail to find out how long it has been there on a curve or on a tangent. And it is not a difficult matter to find out how long it has been there.

Mr. Ray: It is difficult to tell exactly how long rail will wear on a curve. It must be remembered that you must have the same identical kind of rail on the curves that you are comparing. On the Lackawanna we have several curves that we use as test curves, and we make comparison by laying alternate rails around the curves, 10 of one kind, 10 of another and 10 of another. We find, for example, that 10 rails of one sort will wear off about half as fast as the next 10 rails, and you can readily see, if you are going to make a fine calculation, the rate of wear on different degrees of curvature. You have got to have the conditions the same, you have got to have the same kind of rails.

Mr. Howard: We did not intend to offer that as a conclusion. We simply stated that the data submitted by the Pennsylvania Railroad seemed to indicate that,

and we have asked for additional data which will either corroborate or disprove it. That is the only data we have, and that is what it seems to indicate.

J. L. Campbell (E. P. & S. W.): I don't believe that the case for this diagram is quite as uncertain or bad as Mr. Ray seems to think, for the reason that, as I understand, it is the result of observations on two operating divisions and a variety of curves, and no doubt a variety of rails and quality of rails; but in so far as this data has been correctly gathered and studied it helps to get the result of the whole thing, consequently it does have some value.

J. G. Sullivan: When I was making a little study of curve resistance and tried to find out about what percentage of ordinary freight car wheels were removed from the cars for sharp flanges, in cases where one flange only was sharp, I got that information and it averaged about 75 per cent. In connection with that study, it would lead me to believe that the friction wear is a little less on high elevated track than on lower, contrary to what a good many of us, at least what I had in mind, there was not sufficient coning of the wheels to take up the difference in length say of a 12 or 14 or 16 deg. curve.

Mr. Campbell: Just as a matter of information, I may say on the subject of lubricating the rail that we have a branch line going up a mountain about 4,000 ft. in 26 miles. It is built on a 5 per cent grade and has about 230 curves in it. That road was built twenty years ago, and 60-lb. rail were laid there. That original rail is still in the track. When the road was put into operation the rail began wearing so fast that it attracted attention. Since that time, the rails of that track have been lubricated with water. After that had been in operation for perhaps ten years, the management ordered the lubrication discontinued. Immediately the wear of the rail became aggravated with constant derailments. The result was that we put the lubricator back on the engine, and it is working there today with very satisfactory results.

(Mr. Howard's motion was then put to a vote and carried, and the committee was excused with the thanks of the association.)

Closing Business

The Chairman: The chair will announce the ballot preliminary to the installation of officers. (The Chairman then read the result of the ballot.)

The Chairman: I will ask Mr. Wendt and Mr. Sullivan to escort the newly-elected president to the platform. (Applause.)

Mr. Stimson was then escorted to the chair and installed. After a few remarks, he declared the convention adjourned.

W. A. Webb on Board of Adjustment

W. A. Webb, until recently general manager of the Missouri, Kansas & Texas Railroad of Texas, has been appointed a member of the Railroad Administration Board of Adjustment with office in Washington.

Conference on Steel Prices

A committee representing the steel interests was in conference with the Industrial Board of the United States Department of Commerce at Washington on Wednesday and Thursday in an endeavor to reach an agreement on steel prices. No definite agreement was reached on Wednesday, but an early conclusion of the negotiations is expected.

A. R. E. A. Registration

Following is the registration of the members and guests at the convention of the American Railway Engineering Association on Thursday:

Members

Bachelder, F. J., Consulting Engineer, Chicago, Ill.
Bettle, F. W., Gen. Roadmaster, Texas & Pacific Ry., Marshall, Tex.
Busch, Harry F., District Eng., St. L.-S. F. Ry., Springfield, Mo.
Dawley, W. S., St. Louis, Mo.
Hawthorne, F. M., Asst. Div. Eng., Penn. Lines, Pittsburgh, Pa.
Heggie, W. G., Office Engineer, Grand Trunk Ry., Western Lines, Detroit, Mich.
Hopkins, A. T., Field Eng., Val. Dept., M. C. R. R., Detroit, Mich.
Sarvey, A. L., Val. Eng., M. C. R. R., Detroit, Mich.
Smith, C. E. (In military service.)
Snyder, G. D. (In military service.)
Stradling, D. W., Asst. Val. Eng., D. T. & I. R. R., Springfield, Ohio.
Taylor, D. M., Asst. Val. Eng., W. & L. E. R. R., Cleveland, O.
Tuthill, G. C., Acting Br. Eng., M. C. R. R., Detroit, Mich.
White, R. C., Asst. Ch. Eng., M. P. R. R., St. Louis, Mo.
Wonson, S. L., Bridge Eng., M. P. R. R., St. Louis, Mo.
Wood, B. A., Chief Engineer, M. & O. R. R., Mobile, Ala.

Guests

Austill, H., Br. Engr., M. & O. R. R., Mobile, Ala.
Stewart, Geo. H., Supvr., P. R. R., Greensburg, Pa.
Andrews, A. G., Supvr., Penna. R. R., Osceola Mills, Pa.
Tefft, J. F., Asst. Eng., P. M. R. R., Saginaw, Mich.
Abrams, D. A., Lewis Institute, Chicago.

Record Breaking Convention Attendance

President Stimson announced at the close of the session yesterday afternoon that the total registration of members aggregated 509. This is the largest number which has ever been present at a convention, the previous record being 425.

Coliseum Attendance

The attendance at the Coliseum aggregated 23,295, by far the largest in the history of the Appliances Association. It was divided as follows: Monday, 2,612; Tuesday, 6,457; Wednesday, 7,246; Thursday, 5,980.

Col. F. W. Green Returns

Interest was added to the presentation of the report of the Committee on Economics of Railway Operation yesterday, when its chairman, Col. F. W. Green, presented the report. He has been overseas 19 months and only landed in this country on March 7. In the course of his remarks he took occasion to comment on the prestige which the American Railway Engineering Association has built up for itself in France. He stated that in his talks with French engineers he used to ask them if they read any engineering literature published in America, and he did not find one who was not a regular reader of the proceedings of the association. In their estimation the A. R. E. A. is the outstanding and prominent association in the United States.

C. & N. W. Division Signal Foremen Banquet

On Wednesday evening 21 division signal foremen of the C. & N. W. participated in a banquet and get-together meeting at the Winter Gardens, Chicago. Many of these men were heretofore unknown to each other, so that the meeting was planned for the purpose of enabling them to become acquainted with one another and discussing problems of mutual interest.